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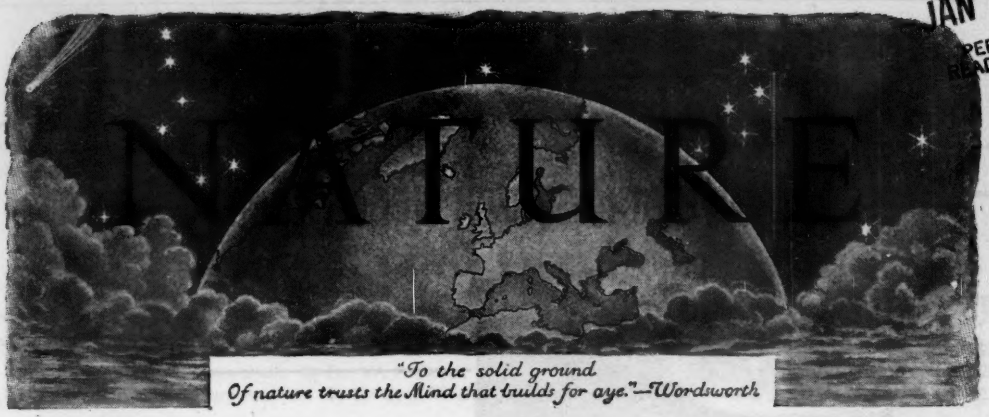

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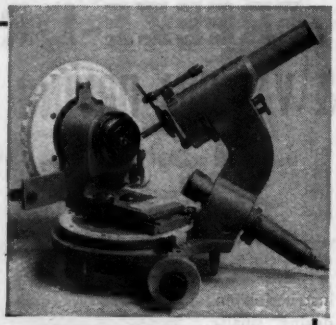

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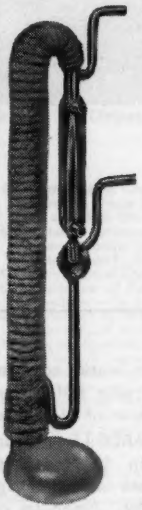

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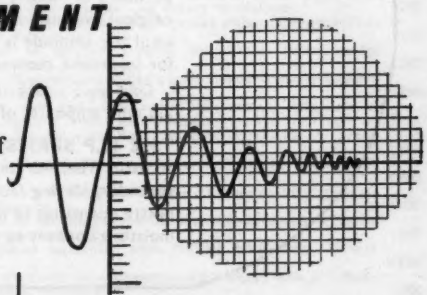

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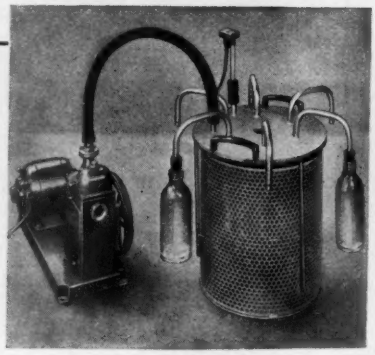

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NATURE

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RESEARCH AND THE RESEARCH WORKER

IN the Fourth Fawley Foundation Lecture, "The Strategy of Research", given at the University of Southampton on October 17, Sir George Thomson discussed the factors which make for success in research, both in societies and in individuals. Sir George did not attempt more than a few tentative answers to such questions as why science has taken so long to get established and why it has made false starts; whether the present high rate of discovery is likely to slow down; or what are the most favourable conditions and how far such favourable conditions can be ensured. These questions have been widely discussed in the past fifteen years in these columns and elsewhere, notably in the Barlow Report on scientific staff; but if Sir George Thomson said little that was new, he gave a fresh emphasis to certain points that frequently tend to be overlooked. Moreover, while in title his lecture recalls Sir Henry Tizard's Messel Memorial Lecture, "The Strategy of Science", given before the Society of Chemical Industry five years ago, and the two lectures have something in common, Sir George Thomson's lecture is essentially complementary to the other.

By the strategy of science, Sir Henry Tizard meant the art of so directing the application or advance of science as to make the most rapid progress of society or knowledge. The tactics of science, on the other hand, are to be understood as the procedure—the skilful devices—calculated to gain the strategy, or, in other words, 'research'. Nevertheless, although Sir Henry might appear thereby to deny the title of 'strategy' to Sir George's lecture for that of 'tactics', in fact both addresses insist on the importance of flexibility in outlook, penetrating thought as to the objectives that really matter, the avoidance of dogma and dispassionate minds in reaching conclusions.

Sir George Thomson was concerned, in the main, with the individual; and although he glances at the organization of research, it appears to be rather as the form of organization affects the productivity or creativeness of the research worker than in relation to its appropriateness or the intrinsic advantages of particular forms. Scientific research, he pointed out, demands an inquiring mind, sustained by the belief that some of the questions it asks have real and discoverable answers, and it must have both leisure and freedom. Further, it is essential not merely to ask sensible questions but also to know the kind of answer that it is reasonable to expect; and this is obviously allied to what Sir George claimed is the most important gift of all in research—that of choosing the right subjects.

This gift Sir George regards as rare, and he commented severely on the tendency to work on unpromising subjects and on the failure to break off an investigation when it no longer seems likely to be productive. This faculty is of supreme importance for a director of research, and while Sir George did not minimize the difficulties involved in expenditure of both time and money in discontinuing a project, he was emphatic that it is as important to make bold and wise decisions here as in the selection of projects originally. Neither in discussing the individual qualities needed for success in research nor in considering the merits of different forms of organization did he appear to attach much importance to the ability of a director of research to handle his men wisely, and it is implied rather than explicitly stated that the director should possess qualities similar to those of the research worker—ability above average, the capacity to understand difficult ideas and grasp their interrelation, to assimilate a considerable mass of fact without being swamped by detail. If the director himself is not called upon to handle complicated apparatus without forgetting the main purpose, there are other duties which make analogous demands, and, like the research worker, his duties must allow him reasonable time to think if not also to experiment in the laboratory.

It seems to follow that, if the director possesses the qualities Sir George Thomson considers necessary in the research worker, he will have that intimate understanding of the mind and outlook of the research worker which is stressed as so important by Sir Henry Tizard; this will help him in using his authority to provide adequate equipment and services and to maintain the conditions most fruitful for creative work. Moreover, those conditions—perhaps especially those touched upon by Sir George Thomson, in quoting a well-known passage from his father's "Recollections and Reflections"—which stimulate critical judgment and new ideas, are the conditions most helpful to the research administrator in arriving at the difficult decisions as to the selection and discontinuance of projects. It follows emphatically from what is said in this lecture that seniority has its dangers in the direction, as in the execution, of research. There may well be a limit to the fruitful life of a director of research as there usually is to that of the investigator himself, and the further study of this aspect of the organization of research, for which Sir George Thomson pleads, might yield a really important contribution to the wise use of trained man-power.

Attention to such matters in our present shortage of scientific man-power is essential if first-class men are not to be wasted on second-class objectives. Moreover, in work that particularly demands originality and imagination and leisure to think, it cannot be too often emphasized that hours and other conditions of work have no relation to those best suited for routine and repetitive work. What is most efficient and even essential in one sphere may waste valuable assets in another. Sir George Thomson frankly suggests that the five-day week is wasteful

for research. The breaks are too frequent and long, and this is a factor that should perhaps be given more weight in deciding the allocation of scientific research between a university institution and an industrial establishment, and certainly in considering the development of technological institutions and their role in industrial research.

In considering the three main types of research organization in Great Britain, Sir George placed the universities first from the point of view of supplying the most fruitful conditions for creative work, and especially in their steady stream of young and able minds who are not likely to accept without question traditional ways of looking at things. Against this immense advantage, the provision of services is bad; and though he did not enlarge on this, the improvement of such services, especially the ratio of mechanics and assistants to graduates, is one way in which for small expenditure the country's research effort could be greatly improved.

Sir George Thomson thinks that the serious difficulties of Government research establishments in Britain, particularly in securing a steady stream of fresh minds and in eliminating those who have lost their enthusiasm and ability for research, outweigh their advantages. He suggests that Government science would be more fruitful if a man's stay in one establishment were limited to ten or twelve years, so that most men would serve in at least three during their working life. Like Sir Henry Tizard, he believes that since the War the Government has been taking too large a share of limited resources of men capable of scientific research, and he urged the importance of increasing the opportunities for scientific research at the universities. Of industrial establishments he said little, though recognizing that they are responsible for much first-class work; but he thought that holidays are too short and ill-arranged and that contact with other workers in the same field could be improved.

For the improvement of research generally, Sir George thought that the formation of temporary teams of men from different institutions but working in one building on a specific problem, as proposed by P. Kapitza, have real advantages in preventing stagnation. To some extent the device is already used by the Road Research Board and in the establishments of the Atomic Energy Authority; but the dispersal when a problem has been solved is important. He also stressed the need for attention to the problem of relieving the head of a large university department of administrative work so that he has sufficient time for research.

As regards the future of research, Sir George does not believe that there is any real limit to discovery or even to what is worth discovering. There is a serious difficulty inherent in the increase of knowledge; and a man may have to know so much before he reaches the frontiers of knowledge that he will have lost his originality. It is very likely that he would go by such a narrow path and be so specialized as to be unable to appreciate what other people are doing. Each divergent line of research would gradually degenerate and die out for lack of cross-fertilization with other lines, and this, if anything, probably determines the real limit to knowledge. This is a long way off, but it was in this connexion that, after stressing the value of good abstracts in helping to cope with the relentless growth of literature, Sir George urged that it is of the first importance to encourage men whose business it is to interpret scientists to one another. In addressing the Library Association recently, Dr. J. Bronowski suggested that the publication in one series of the old and new classics of science would help to make the language of science familiar to a new generation, and his plea for more classics of science looking at new discoveries in a personal way found an echo in Sir George Thomson's plea for encouraging the interpreter of science to non-scientific audiences. It is also important, he believes, to encourage the interpretation of advances in one science to workers in another, and even of one branch to those working in another branch of the same science. Sir George does not think that this could usually be done by the specialist himself. It is usually done best by a man who has got up the subject for the purpose, and such men should be given adequate recognition in scientific circles.

The real menace to the advancement of science, however, is loss of freedom, above all, freedom to think. Even here Sir George was optimistic, though his address sets in its rightful perspective the current discussions about academic freedom in the universities of the world. No less important is that he indicates the way in which theories of morality, as well as political doctrines, particularly the view that a scientist is responsible for the consequences of his discoveries even if he has not foreseen them, can threaten freedom.

Apart from this glance at the future and the review of the development of science with which it began, this Fawley Foundation Lecture might be described as an exposition of the theme that wise rather than large expenditure is what matters in research. No less clearly than Sir Henry Tizard, Sir George points to Government neglect as largely responsible for the current waste of resources of trained man-power: the significance of such projects as the National Science Centre and both the National Reference and Lending Libraries for science and technology is clearly seen in the context of his restrained but incisive remarks about the exchange of information and the meeting of minds. If, however, the Government is to be turned from its mistaken ideas as to how to economize in scientific and technical matters, scientists and their professional associations must use to the full the arguments which Sir George Thomson has outlined, both in pressing such views on the Government and in developing for themselves increasingly efficient means of securing the interchange of men and of information and establishing the conditions in which creative work is most fruitful and effective.

THE 45-FT. RADIO TELESCOPE AT THE ROYAL RADAR ESTABLISHMENT, MALVERN

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RADIO methods of observation have extended to many branches of astronomy during the past ten years, and have led to contributions of considerable importance both to radio and to astronomy. This field of research includes the study of radar reflexions as well as radio emissions from astronomical bodies, gaseous media, and associated astrophysical phenomena. The application of radar is limited to comparatively near objects in the vicinity of the Earth or within the solar system, but it has the advantage of providing an accurate measurement of range.

Although progress in radio astronomy has been rapid, it depends much on advances in radio techniques. A basic need is for improved sensitivity and angular resolving power. Both these demands can be fulfilled by increasing the aperture of the aerial used for the radio telescope. A limit to size is set by practical considerations, since very large steerable aerials tend to become vast mechanical structures which are consequently expensive and take a long time to construct. Also, the larger the aerial the more difficult it is to achieve the accuracy of surface necessary for short radio wave-lengths.

These conditions were in mind when the radio telescope here described was planned early in 1956. A parabolic reflector was specified so that the aerial could be used over a wide range of wave-lengths. It was decided to economize by adapting an old radar-turning mechanism, raised on a tower, as the mount for the reflector. This imposed a restriction on the size of the reflector; but it was consequently more practicable to achieve the desired accuracy of the surface.

There were several reasons for designing the radio telescope to work down to short wave-lengths of 10 cm. or less. The smallest angle which can be resolved is approximately equal to λ/D, the ratio of the wave-length to the diameter of the telescope aperture. Hence, although the power received is proportional to the collecting area, and thus to D^2, the angular resolution is improved if λ can be made small. If the telescope is used as a radar, then the power transmitted is contained in a beam of width approximately λ/D radians (and hence of solid angle $\approx\lambda^2/D^2$). Consequently, the shorter the wave-length the more the power is concentrated on the radar target by a factor proportional to D^2/λ^2. The relationship between diameter and wave-length for the combined transmitter–receiver aerial system is thus D^4/λ^2 in power sensitivity, which means a factor $D/\sqrt{\lambda}$ in maximum detection range. If other parameters were constant, then the detection range could be improved by increasing D or by reducing λ. Many phenomena, for example, emissions from 'radio stars' or radar reflexions from meteor trails, are, however, very much more intense at longer wave-lengths. Radio astronomy at these wave-lengths is now strongly represented by the work at Jodrell Bank (University of Manchester) and at Cambridge. In comparison there has been little work in Great Britain at centimetric wave-lengths, although research

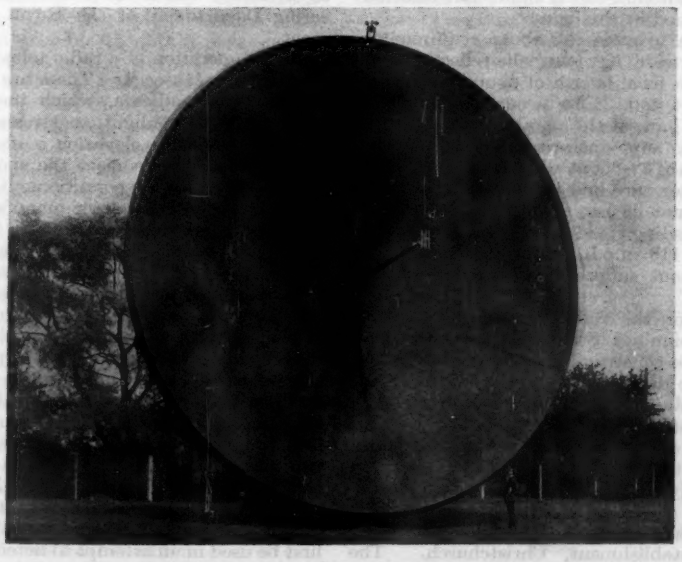


Fig. 1. The radio telescope at Malvern, showing the aluminium surface

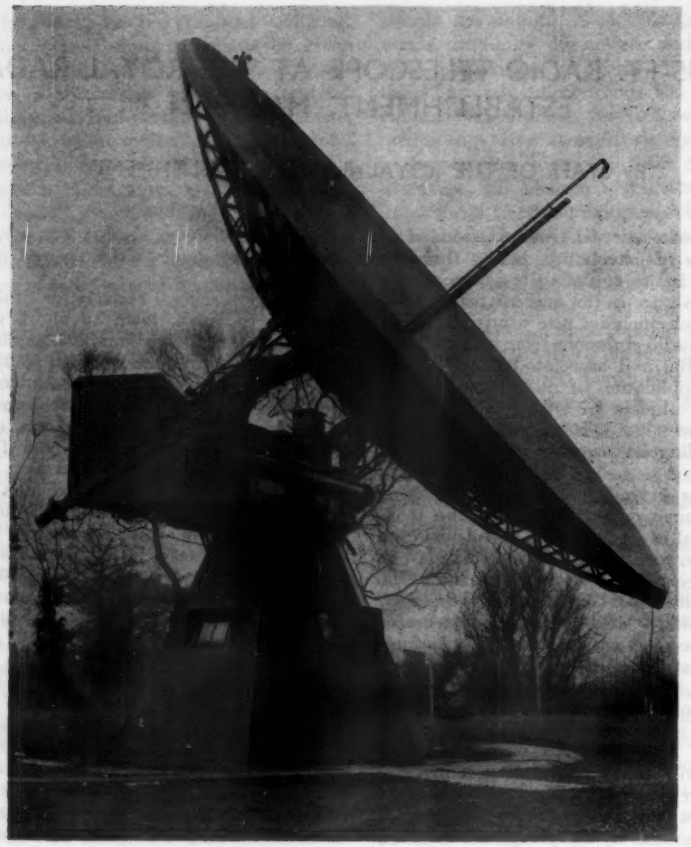


Fig. 2. The radio telescope, showing the supporting structures

elsewhere has shown that much significant information may be obtained in this band.

The specification to meet the above requirements stipulated the provision of a parabolic reflector 45 ft. in diameter, with a focal length of about 20 ft., and weight less than 4 tons. An accuracy of surface contour within $\pm \frac{1}{4}$ in. of the parabolic form had to be maintained in any operating position, which included elevations of 5°–85° at all azimuths in various conditions of temperature and in steady winds up to 30 m.p.h. When not in use, the reflector had to be capable of withstanding steady winds up to 60 m.p.h. with gusts up to 110 m.p.h., and the deposition of ice or snow, without suffering any permanent distortion.

The contract for the reflector was placed with Precision Metal Spinnings (Stratford-on-Avon), which agreed to complete construction and erection in less than a year. The design was prepared by the consultant firm of Messrs. Jenkins and Potter. The framework, consisting essentially of two rings connected by curved radial arms, and the riveted plates forming the reflector surface, were all manufactured in aluminium supplied by the British Aluminium Co. The radar tower was designed and constructed by the Ministry of Supply at the Military Engineering Experimental Establishment, Christchurch. The engineering planning of the whole scheme was co-ordinated and assisted throughout by the Engineering Department of the Royal Radar Establishment.

In the operation of a radio telescope, several types of distortion can occur. These are principally due to temperature gradients, which may be particularly pronounced in sunlight, to stresses due to gravity, which alter as the elevation is changed, and to the effects of wind. To meet the specified tolerance of $\pm \frac{1}{4}$ in. in operating conditions, it was consequently necessary to impose closer manufacturing tolerances of $\pm \frac{1}{16}$ in. at the centre of the bowl and $\pm \frac{1}{8}$ in. at the periphery. The reflector was assembled at the prepared site in Malvern during winter months and, despite adverse weather conditions, the telescope was satisfactorily completed and mounted within a year of placing the contract. Due to the incorporation of turning mechanisms from old equipment, the principal item of expenditure was the parabolic reflector, and the total cost was of the order of £10,000. As an example of the improvization to keep the cost low, the support for the instruments at the focus of the telescope is a steel telegraph pole bought from the General Post Office for £3 0*s.* 3*d.* The completed radio telescope is shown in Fig. 1.

It was originally intended that the telescope should first be used in an attempt to detect the radio spectral line from deuterium in the galaxy at a wave-length of

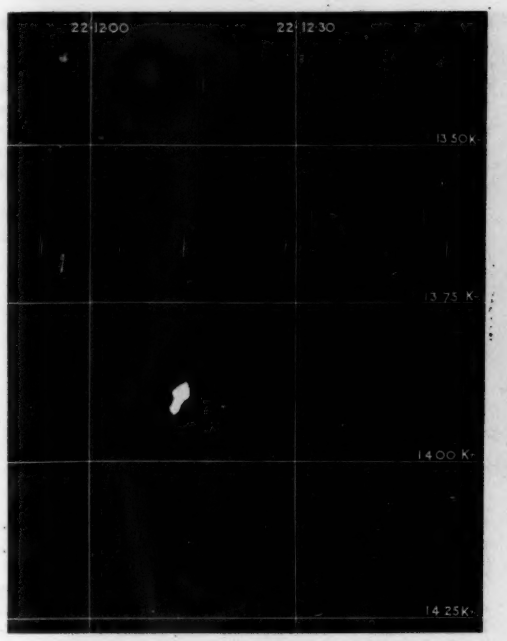


Fig. 3. Radar echo of the first Earth satellite rocket observed on October 30

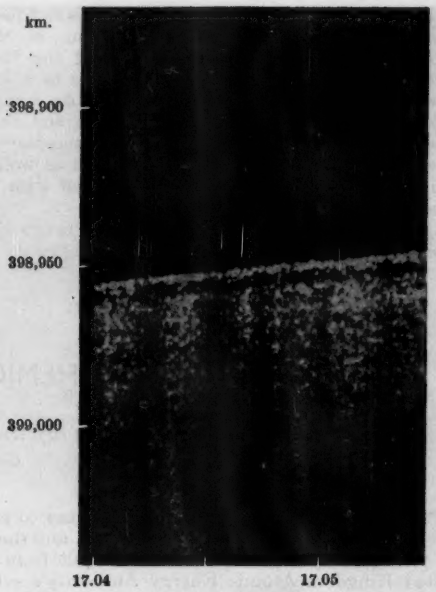


Fig. 4. Radar echo of the Moon, showing distance from radar to Moon's surface in kilometres against Universal Time

91 cm. An extremely sensitive radiometer, capable of measuring changes of aerial temperatures of less than 0·1 deg. K., was constructed. The receiving dipole and reflectors for this experiment can be seen in Fig. 1 at the focus of the telescope, and observations were about to commence when the first Russian Earth satellite was launched. It was then decided to suspend the deuterium line measurements temporarily, and instead to accelerate a later development which had been planned in the research programme, the building of a 10-cm. radar transmitter and receiver into the radio telescope, since this would make it possible to obtain radar echoes from the satellite and its rocket. Several departments within the Royal Radar Establishment co-operated in the construction of the apparatus, which by an intensive effort was completed within three weeks. Essentially this equipment consists of a high-power radar which operates at a wave-length of 10 cm., radiating a peak power of 2 megawatts with a pulse length of 5 μsec., a receiver of 500 kc./s. bandwidth, and appropriate display units. The waveguide and horn at the focus of the radio telescope can be seen in Fig. 2.

The field of view of the radio telescope at this wave-length extends over an angle of only $\frac{1}{2}°$. It had been hoped that predictions deduced from the radio-interferometer measurements of the satellite transmissions at 40 Mc./s. combined with visual observations would have been sufficiently precise to direct the radio telescope within $\frac{1}{2}°$ of the paths of the satellite and rocket; but unfortunately, this has so far proved a major problem. However, on several occasions since October 30 radar echoes have been received from the rocket and these have been of strong intensity at ranges of about 1,400 km. Fig. 3 shows a photograph of a radar echo of the rocket of the first Earth satellite on a brightness-modulated display with the radar beam maintained in a fixed direction. The form of the echo indicates a scintillation of echoing area due to the varying aspect of the rocket as it passed across the beam. It is estimated that the first Earth satellite itself, assuming it is a metal sphere of radius $r \approx 30$ cm., and hence echoing area $\pi r^2 \approx 0{\cdot}25$ m.^{2}, would be detectable up to ranges of about 1,000 km. A radar reflexion from the second Earth satellite was first detected on November 14; but it is understood that the carrier rocket is an integral part of the satellite.

The equipment has also successfully observed radar echoes from the Moon, which are of special interest because they are obtained at centimetric wave-lengths using a short pulse-length, and hence capable of giving precise measurements of range. Previously reported radar observations of the Moon have been with pulses usually several milliseconds in duration. These are long enough to encompass most of the Moon's surface in the returned echo, and measurements of range are correspondingly inaccurate. In

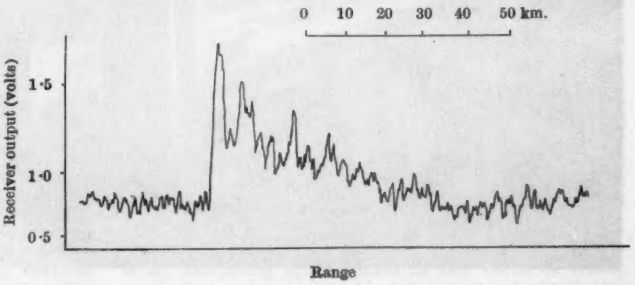


Fig. 5. Amplitude of the Moon echo

the radar here described the pulse-length was 5 μsec., equivalent to a distance of about 1 km., so that echoes from each part of the surface of the Moon corresponding to increments of the order of a kilometre in depth can be distinguished. As a short pulse-length reduces the area of the surface illuminated within a pulse-length, it becomes necessary to have an equipment with high aerial gain as well as high peak power. This has been achieved with the present equipment.

A photograph of the Moon echo on the range–time display is shown in Fig. 4. The echo begins at the nearest part of the Moon's surface and the range drifts with time due largely to the movement of the observing site with the rotation of the Earth. Because of the initial sharp rise of echo intensity, as illustrated in Fig. 5 by the photometric analysis of the photograph, the range at any instant may be found to an accuracy of the order of a kilometre, which is better than that obtained so far by optical methods.

Acknowledgment is made to the Controller, H.M. Stationery Office, for permission to publish this communication.

THE RADIOCHEMICAL CENTRE, AMERSHAM

By Dr. W. P. GROVE
General Manager

THE demand for radioisotopes continues to grow vigorously both at home and abroad, and during the past three years the combined output from the United Kingdom Atomic Energy Authority's establishments at Harwell and Amersham has more than doubled. The larger part of the work of making and distributing these versatile materials now falls upon the Radiochemical Centre, which will have sent out nearly twenty thousand consignments this year.

To keep pace with the demand a new laboratory of 12,000 sq. ft. (Fig. 1) and a block of offices have been erected at Amersham, and these were opened by Lord Salisbury on November 1 in the presence of

Fig. 1. A general view of the laboratories showing the new block in the background

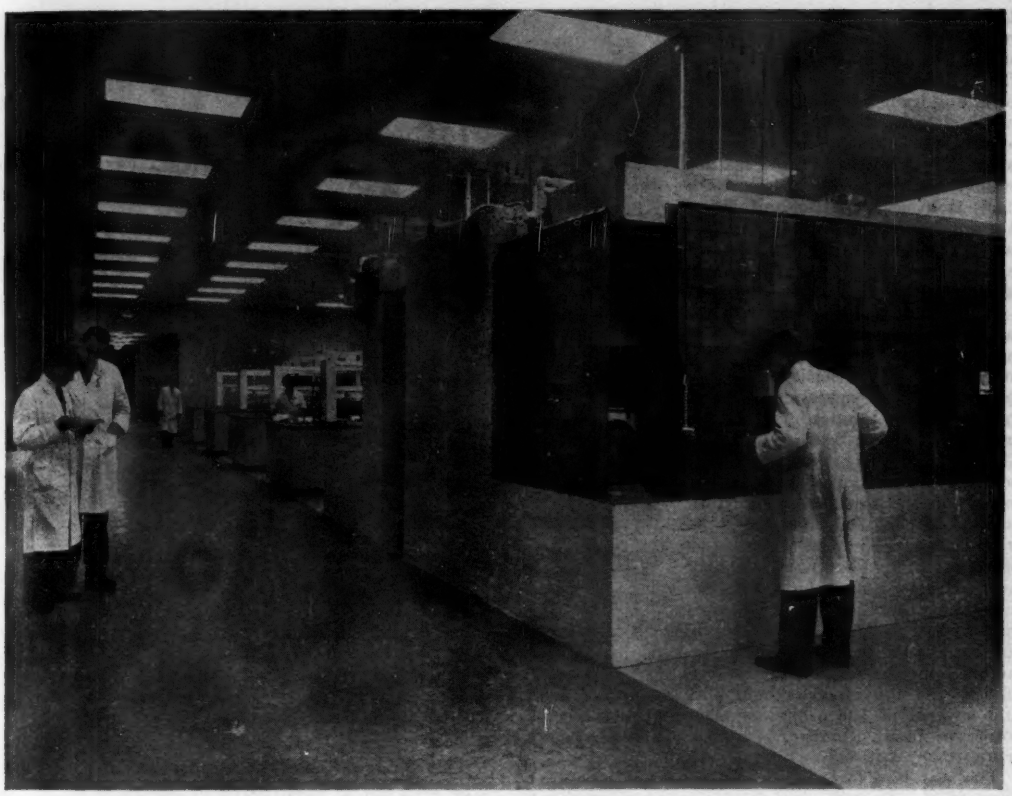


Fig. 2. A general view of the isotope laboratory in the new technical building

Sir John Cockcroft, Sir Henry Dale—who opened the first group of isotope-processing laboratories in 1954 (*Nature*, **173**, 1067; 1954)—Sir Ernest Rock Carling and other distinguished guests.

The new laboratory is to house processes with beta- and gamma-emitting isotopes. It is needed because of the increasing radioactive scale of operations, the greater diversity of radiochemical work and the higher standards of protection that are now in vogue following the latest report of the International Commission on Radiological Protection (1955). Whereas the older plants were shielded for amounts of gamma emitters of ten to fifty curies, the present need is for equipment capable of handling a thousand curies. Also for large amounts of beta emitters, which may not require heavy shielding, it is still necessary to provide for effective containment within 'gloved' boxes and to exercise strict radiological control. A large part of the new laboratory is devoted to this type of work and a versatile system of 'gloved' and 'tonged' boxes has been installed (Fig. 2).

In particular, the facilities for processing fission products are being improved. Cæsium-137 and strontium-90 have to be manufactured into the various special forms required by industry, as, for example, sources for industrial radiography and for thickness gauges. There is also a need for more of the 'minor' fission products—promethium, cerium-144, yttrium-90, zirconium and niobium-95. For these purposes a 'hot cave' facility is being constructed to accommodate activities up to one thousand curies of cæsium-137. It comprises three inter-connecting compartments which are shielded by three feet of high-density concrete bricks. Vision is obtained through liquid windows of concentrated zinc bromide solution and manipulation within the cells is done with the aid of three pairs of the Argonne pattern of master-slave manipulators. As these caves are intended for chemical work with highly toxic materials, it has been necessary to provide them with enclosed metal liners, each measuring about 7 ft. × 8 ft. × 15 ft., which will be kept under slightly reduced pressure to prevent the escape of radioactive dust. Access to the caves for servicing will be made by the 'captive man suit' technique (Fig. 3).

Labelled Compounds

The demand for some of the less-common isotopes, and particularly for labelled compounds containing iodine-131, phosphorus-32 or sulphur-35, has now grown sufficiently to warrant formal chemical plants for producing them. The number of separate syntheses of labelled compounds (other than carbon-14) has risen to more than five hundred this year, incorporating some twenty different isotopes. There is an increasing appreciation of the value of tracer methods in chemical technology, particularly in the

study of such specific chemicals as weed-killers, pesticides, fertilizers, rubber additives and detergents. The use of labelled drugs for determining their mode of action and metabolic fate, and of special compounds as diagnostic aids is also increasing steadily. An interesting recent example (*Nature*, **178**, 799; 1956) is a study of the uptake of 'Dapsone' (diamino-diphenyl-sulphone) in the skin and tissues of leprosy patients by using the drug labelled with sulphur-35.

For tracer studies, carbon-14 remains pre-eminent and many new compounds labelled with this isotope have been synthesized recently for use by biochemists and others: more than two hundred compounds are now available from Amersham. The synthesis of generally labelled benzene and toluene has been much improved, and so the simpler aromatic substances are now accessible with ring labelling. Other classes of compound which have recently received attention include the steroids (chloresterol, testosterone, progesterone, œstrone), the carcinogens dibenzanthracene and benzanthracene, specifically labelled sugars (glucose labelled in the 1 or 2 or 6 position, ribose, sorbitol, gluconic acid and glucuronic acid), and several of the amino-acids specifically labelled (DL-tryptophan, 5-hydroxytryptamine and 5-hydroxytryptophan, L-histidine and L-serine).

The standard of labelled compounds is constantly improving. Specific activities are now commonly five to ten millicuries per millimole, compared with one to two millicuries per millimole three years ago, and they may be much higher in exceptional cases. The best samples of carbon-14 carbonate to-day are nearly 50 per cent isotopic abundance, as compared with less than 2 per cent three years ago. The technique of gas-phase chromatography has done much to improve chemical purities, and standards are now generally much higher than has been customary with inactive chemical reagents. In some cases the limit of radiochemical purity is now set by the susceptibility of a compound to decomposition under its own radiation. Techniques for preserving labelled materials against this effect are being studied.

Biochemical methods of labelling are becoming more important. The scale of production of generally labelled sugars by photosynthesis in green leaves and of protein by growing the alga *Chlorella vulgaris* has been increased some ten times, and it is not exceptional to commit a curie of carbon-14 in a single batch. This larger scale of working has led to improved stocks, to a better quality of generally labelled amino-acids, and to useful quantities of certain minor components such as the nucleic acid fractions and lipids.

Human serum albumin iodinated with iodine-131, which has been in regular production since January 1955, is finding increasing application in diagnostic procedures such as the measurement of blood volumes and cardiac efficiencies. It may also have therapeutic possibilities. Another compound of considerable medical interest is vitamin B_{12} labelled with one or other of the cobalt isotopes—cobalt-56, -58 or -60. A process for making radioactively labelled B_{12} has been devised with the co-operation of Glaxo Laboratories and the first product labelled with cobalt-58 will be available in January.

Fig. 3. A 'captive man suit' of plastic is viewed by (left to right) Dr. W. P. Grove, general manager of the Radiochemical Centre at Amersham, Lord Salisbury and Sir Henry Dale

Radiation Appliances

Notwithstanding the great variety and quantity of radioisotopes now produced artificially, the use of natural radioelements has not declined. During the past three years some eight thousand clinical radium needles and 120,000 radon seeds have been manufactured—mainly for British hospitals, but partly exported. The production lines for filling radium containers, which is an unusually delicate and exacting operation, have recently been entirely rebuilt so that all manipulations are now done by remote control and the work is totally enclosed. A new plant has also been installed for producing polonium–beryllium neutron sources which are now in demand industrially for well-logging and for reactor experimentation. Each source usually contains between five and ten curies of polonium.

For beta emitters which are to be used clinically or industrially, the preferred form is in metal foils or plaques, and these are produced with a number of different isotopes — strontium-90, thallium-204, cerium-144, ruthenium-106—according to the beta-ray spectrum required for particular applications. Some eight thousand sources of this kind have been manufactured during the past three years, mainly for thickness gauges and static eliminators. Improved manufacturing techniques make it possible to handle much larger quantities of beta emitters in this way, and a radiating unit containing ten curies of strontium-90 has recently been made for therapeutic use. In collaboration with the Royal Marsden Hospital, special applicators have been designed to fit in contact with the eye, and these are being used for improving corneal grafts and treating certain disorders of the eye.

THE ROYAL SOCIETY

ANNIVERSARY ADDRESS*

By SIR CYRIL HINSHELWOOD, F.R.S.

AWARD OF MEDALS, 1957

Copley Medal : Sir Howard Florey, F.R.S.

PROF. FLOREY has made a number of outstanding contributions to experimental pathology and medical science. He is best known for his work in connexion with the isolation and detailed study of penicillin and its development as a successful non-toxic anti-bacterial agent for use in medical treatment. It is difficult to over-emphasize both the scientific importance and the practical value of this contribution.

He described his earlier work on mucin and its functions in the Croonian Lecture of the Society of 1954. Since then, with his collaborators, he has carried these investigations considerably further, in particular by the development of auto-radiographic methods depending upon the use of sulphur-35. Florey's work on Brunner's glands, in which he determined the nature and mode of their secretion, is considered to be an outstanding contribution to this subject. In his studies of acute inflammation and the development of tuberculous foci in the living animal, he made use of the transparent-chamber technique and of cinematography to clarify the part played by the various types of cells. By using coloured vital dyes he investigated the penetration of substances into tuberculous lesions.

His investigation of the effects of cortisone on cell division in regenerative hyperplasia of the liver and his very recent work on the regeneration of aortic endothelium are also important contributions. In addition, Florey and the workers in his laboratory have continued to work steadily on the discovery, development and mode of action of new antibiotics, including cephalosporin *N*, nisin and micrococcin. In particular, these endeavours have been directed toward the improvement of the chemotherapy of tuberculosis.

All his investigations are characterized by the choice of difficult and worth-while problems and by a fine technique which has usually involved both the development of original methods and the use of methods new to the particular problem.

Royal Medal (A) : Prof. W. V. D. Hodge, F.R.S.

Prof. Hodge has for many years established an international reputation as a geometer of the first rank. He is perhaps most widely known as the creator of the theory of harmonic integrals. Since his exposition of this theory, first in a series of papers in the *Proceedings of the London Mathematical Society*, and later in his book, "The Theory and Applications of Harmonic Integrals", the subject has grown rapidly in scope and importance. The book has been described as one of the great landmarks in the history of mathematics in the present century.

In the application of this theory, above all to algebraic geometry, Hodge has played an important part, and has greatly enriched our knowledge of the transcendental theory of algebraic varieties, and revealed new, and unsuspected properties, among which may be mentioned his 'signature theorem'. He has also shown how many of the results obtained from his theory can be extended to manifolds of a type more general than algebraic ones (Kähler manifolds). He has written on a wide range of geometrical topics besides harmonic integrals ; among his more notable papers are recent ones dealing with the characteristic classes of algebraic varieties, and has recently made (with Atiyah) an important contribution to the theory of double (and multiple) integrals of the second kind.

Hodge has also worked on the purely algebraic aspect of the subject. His three-volume work (with Pedoe) "Methods of Algebraic Geometry" is one of the most important expository mathematical works recently published in Great Britain.

Royal Medal (B) : Prof. F. G. Gregory, F.R.S.

Gregory's work in plant physiology has been dominated by an appreciation of the importance of the responses of the intact integrated organism, and has been of decisive importance for this subject. Early in his career he elaborated a technique which analyses growth in terms of three parameters, the relative growth-rate, the net assimilation-rate and the leaf-area ratio. From variations in these quantities it is possible to assess the primary effects of various environmental factors, and the general technique has been applied with conspicuous success in ecological, physiological and agronomic studies in many parts of the world.

Gregory was a pioneer in studying vegetative growth in a controlled environment. In an investigation based on this technique, he made a detailed examination of the growth of the leaf and produced the first cogent evidence for the operation of a specific chemical stimulant for leaf growth. Since then, he has been particularly concerned with nutritional effects in growth and with the nature of the mechanism that determines the induction of the reproductive phase. The nutritional studies have extended over the past thirty years and they provide the most extensive analysis available of the effects of nitrogen, phosphorus and potassium.

Gregory's studies on the induction of flowering have made him a leading authority on this important subject. He has promoted a series of notable investigations on the low-temperature effect in vernalization and on the day-length effect in photoperiodism. He has shown that short-day-induced *Kalanchoe* may be characterized by a remarkable correlation of a surprising range of phenomena which include flower production, alternative leaf morphology and a biochemical change of induced carbon-dioxide fixation in the dark accompanied by acid production followed by carbon-dioxide release in the light which is accompanied in turn by conversion of acid to carbohydrate. The demonstration of the development of these biochemical changes, and the induction of flowering and other morphological modifications when plants are subjected to the appropriate day-length, is one of the major advances in the complex field of plant morphogenesis.

* Delivered at the Royal Society on November 30.

Gregory has also made contributions to the study of leaf-fall, the transport of auxin, transpiration and stomatal movement.

Gregory's indirect influence has been profound, and he has stimulated the interest and activity of many research students who have carried the impetus they received from him to many parts of the world.

Davy Medal : Dame Kathleen Lonsdale, D.B.E., F.R.S.

Dame Kathleen Lonsdale is a pioneer in the field of X-ray crystallography. She joined Sir William Bragg's original team of workers in the early 1920's and made many accurate measurements on the various organic crystals which were at that time being studied in the laboratory. One of her first tasks in this field was of a more mathematical nature, that of working out the consequences of space-group theory in terms of diffraction effects, a task which was completed and published with W. T. Astbury in 1924. The mathematical development has continued to occupy her attention throughout the years, as author and editor.

It is, however, as a careful and accurate experimental investigator that she is most widely known. The great triumph came in 1928 with her complete elucidation of the structure of hexamethylbenzene. This work established the true geometry of the benzene ring for the first time, and paved the way for all future X-ray studies on the aromatic hydrocarbons.

It has been the simple rather than the chemically complex structures that have generally appealed most to Dame Kathleen, and the problems of crystal physics rather than those of crystal chemistry. Her studies of the thermal vibrations of atoms in crystals have been a continuing interest, and she has made outstanding contributions both in theoretical treatment and in very beautiful experimental work to the subject of the diffuse scattering of X-rays by crystals. Her work on the two types of diamond crystal belongs to the same category. Mention should also be made of her work by the method of divergent-beam X-ray photography on the diamond structure, which has enabled the fundamental lattice constant to be determined with extraordinary precision. The great range of Kathleen Lonsdale's interests are indicated and illustrated in her book "Crystals and X-rays".

Buchanan Medal : Sir Neil Hamilton Fairley, K.B.E., F.R.S.

Sir Neil Hamilton Fairley has carried out much research on diverse aspects of tropical medicine and has made many discoveries which have played a part in eradicating or preventing disease.

His earliest work was on immunity reactions in helminthic diseases. He showed that stable antigens could be prepared from helminths at different stages in their development, including the stages found in intermediate hosts, and that these antigens reacted with antibodies in the serum of infected vertebrates. He devised skin tests and complement-fixation tests for the diagnosis of infection with schistosomes and filaria, which have been of great value in making surveys of infection in different communities.

He has carried out researches which had a significant bearing on the etiology and treatment of sprue, and on the hæmoglobin in blackwater fever. In Egypt in 1941 he played a leading part in introducing sulphonamides in the treatment of bacillary dysentery, and showed that sulphaguanidine cured the potentially fatal type caused by Shiga's bacillus.

His most important work has been on the chemoprophylaxis and chemotherapy of malaria. In 1943 he was made director of the Land Headquarters Medical Research Unit at Cairns, Queensland. Here he built up a unit in which large-scale experiments were carried out in human volunteers on the prevention and cure of malaria. Rigid controls were imposed and new techniques were devised. He was able to prove conclusively that quinine, even in doses of ten grains daily, failed to suppress heavy infections with the sporozoites of *Plasmodium falciparum*. He showed that certain sulphonamides which at that time were being advocated as suppressants were not suitable for the type of malaria then occurring in New Guinea. On the other hand, he found that 'Atebrin' ('Mepacrine'), in doses of 0·1 gm. daily, gave complete protection.

This work led to the introduction of 'Atebrin' suppression, and the incidence of malaria was reduced from 740 per 1,000 in 1943 to 29 per 1,000 in 1945. He also assessed the value of the 4-aminoquinolines and later of 'Paludrine', both for suppression and for therapy.

Apart from these practical findings, his observations have thrown much new light on the life-cycle of the malaria parasite.

Fairley's work has been the basis of all subsequent investigations on malaria suppression and therapy, and in its application has been of incalculable value to the health of all tropical populations.

Hughes Medal : Prof. J. Proudman, C.B.E., F.R.S.

Prof. Proudman has carried out research on physical oceanography over a period of forty-five years. Outstanding among his earlier papers are a series in which the dynamical equations of the tides are used in a form which involves an infinite sequence of discrete co-ordinates. During the past ten years, his main achievements are the writing of a book, "Dynamical Oceanography", published in 1953, and his researches on the interaction between tides and storm-surges in estuaries.

In his work on storm-surges he was the first to obtain definite and applicable results on the dynamical interaction between tide and surge. He has obtained precise results for the two cases in which the combination of tide and surge in an estuary is (1) a progressive wave, and (2) a standing oscillation. Defining an 'apparent surge' as the excess of the disturbance of sea-level over that of the predicted tide, and taking a surge at the mouth of an estuary to be determined by the sequence of meteorological conditions over the sea, his chief results may be expressed in terms of the apparent surge at a place up an estuary due to a given range of tide and a given sequence of meteorological conditions over the sea. In the case of a progressive wave, the maximum apparent surge is less when it occurs at the time of tidal high water than when it occurs at the time of tidal low water, while in the case of a standing oscillation, the exact opposite holds. But both for a progressive wave and for a standing oscillation, the maximum apparent surge is greater when it occurs three hours before tidal high water than when it occurs three hours after tidal high water. These

results have application to the incidence of coastal flooding.

Proudman's book is the only one on dynamical oceanography in the English language. In a review of it by a leading dynamical oceanographer there occurs the phrase "Publication of this splendid volume makes one feel that oceanography has at last come of age".

The year which is now closing has been eventful, and I can only mention a few of the many things which have made it so. The Society has had the honour of enrolling H.M. Queen Elizabeth, The Queen Mother among its Fellows. The International Geophysical Year has been successfully inaugurated, and we are grateful to H.R.H. Prince Philip, who in his capacity as a Fellow of the Society gave so auspicious a send-off to this great international scientific adventure. The spoils of the adventure itself are being accumulated, but their evaluation is for the future. It is impossible, however, to pass over in silence the successful launching by our Russian scientific friends of the first artificial Earth satellites —an event which, whatever else it betokens, marks the opening of a new era in human history.

On the personal side there are two matters to which I should like to refer. The first is the award of the Nobel Prize in Chemistry for 1957 to one of our Fellows, Sir Alexander Todd, for his magnificent work in organic chemical synthesis. The other I do with a different kind of feeling, since it is the retirement from the post of secretary on the physical side of Sir David Brunt, who for nine years has filled the office with distinction, and made upon it all the impress of his vivid and energetic character. The Society has very much to thank him for, and I should like to place upon record our most sincere gratitude.

To Dr. D. C. Martin and the staff here, few save the officers can know quite fully—though many know in very varied ways—how much we all owe. It is meet that the president should speak of this to-day, and I hope my words will be noted by those about whom they are most sincerely spoken.

But in the words once made famous by one of our Fellows whose birthday it is to-day, "each to his task". The president by tradition must offer you some scientific reflexions on his own account, however much this involves a departure from the higher themes.

SOME OBSERVATIONS ON THE MECHANISM OF CHEMICAL REACTIONS

In the complexity and elaboration of modern scientific work, the question should occasionally be asked as to the pattern which it all makes. To do this for the whole of science would be an almost superhuman task, but even within the confines of more limited fields the effort is both necessary and revealing. Perhaps I may now attempt a brief elaboration of this theme in relation to a branch of chemistry which has occupied a good deal of my own time over the years and which deals with the intimate mechanism of chemical transformations.

In some ways it is a highly specialized and even abstruse subject, yet it illustrates in its own way a general type of evolution.

Knowledge is pursued for two ends, for power and for understanding. Fortunately for those who believe with the preacher that wisdom is better than strength, the two ends are inseparable. Nobody who has witnessed the developments of the plastics industry, of internal combustion, the production of organic fine chemicals and drugs, or who has seen the many ways in which knowledge of the working of living cells is of value in practical investigations, can fail to realize how fruitful has been the analysis of chemical mechanisms. Nor can those who have studied such mechanisms fail to be impressed and perhaps disconcerted at their luxuriant diversity.

Yet what the true seeker after knowledge in his heart desires is some simple design which he feels must underlie the facts. Nearly a century has gone to the seeking of it. The search for principles which are æsthetically satisfying seems often frustrated by the complexity of Nature, and the conflict between imagination and austere regard for truth seems often to result in the passage of scientific theories through three stages. The first is that of gross over-simplification, reflecting partly the need for practical working rules, and even more a too enthusiastic aspiration after elegance of form. In the second stage the symmetry of the hypothetical systems is distorted and the neatness marred as recalcitrant facts increasingly rebel against conformity. In the third stage, if and when this is attained, a new order emerges, more intricately contrived, less obvious, and with its parts more subtly interwoven, since it is of Nature's and not of man's conception.

The problem of chemical mechanisms has certainly passed through two of these stages. Is there perhaps hope that it is entering the third ?

The major questions of chemical kinetics can be recapitulated in uncomplicated terms. Matter is largely not in equilibrium. What principles govern the inevitable passage towards it ? This is a clear-cut question. To what extent do the answers correspond ?

The very broad lines are set by the principles of energy and entropy. The molecules of a chemical system are in a trough of energy from which they need to be lifted to a transition state of higher energy before they proceed to reaction. The necessary energy is the activation energy, E, derived from the dependence upon temperature of the rate constant, k, by the famous Arrhenius equation $\mathrm{d} \ln k/\mathrm{d}T = E/RT^2$ or $\ln k = A \exp(-E/RT)$.

Since the molecules must pass from an average to a transition or activated state in the reaction, the rate constant can be envisaged as the product of two terms, one dependent on an equilibrium between the transition-state structures and the average structures, the other measuring the rate of passage from the transition to the final state.

By standard thermodynamics an equilibrium constant is related to a free-energy change, and from the connexion between free energy, total energy and entropy follows a well-known formula expressing the rate constant as a product of an entropy term and an energy term,

$$k = (kT/h)\{\exp(\Delta S^*/R)\}\{\exp(-\Delta H^*/RT)\}$$

where ΔH^* is identifiable (nearly) with the activation energy.

In the general expression for a rate constant, $k = A \exp(-E/RT)$, the logarithm of A is a measure of the so-called entropy of activation, and E is the energy needed to take the molecules as it were to the point of no-return : A defines the probability, in respects other than the concentration of energy, that they

should reach there. Thus many of the subtler details of chemical kinetics appear as a reflexion of the great primordial conflict of energy and entropy, order and disorder.

Chemical reactions generally are resolved into simple steps involving, with rare exceptions, one or two molecules only, and the major problems relate, first, to the character of the individual bimolecular and unimolecular steps, and secondly, to the mode of concatenation of these steps into the complete sequence. Each of these various matters has passed through the early stage of over-simplification. A naïve theory of bimolecular reactions served its turn, a primitive theory of unimolecular reactions had its vogue and a rather idealized notion about the sequence of steps in reaction mechanisms as a whole led to the idea that chain reactions involving free radicals must be sharply differentiated from the transformations due to molecules alone.

I shall refer only very briefly to the theory of bimolecular reactions. It began with a fine excess of simplicity on the basis of examples in which the entropy factor could be calculated simply from the probability of collision, $k = Z\exp(-E/RT)$, where Z is the collision number in the appropriate units. The constant A then has a value of about 5×10^{11} l.mole^{-1}sec.$^{-1}$. But examples soon appeared where it ranged from this figure down to one about 10^{-8} times smaller, and others where the entropy factor showed an intriguing functional correlation with the energy factor itself. In some simple reactions the entropy factor has lately been calculated, by Ingold and his collaborators, on the basis of a plausible model of the transition state. But it is premature to say that the essential scheme of things is yet clear.

It is, however, the unimolecular reaction which, on the whole, has been the subject of the most interesting evolution of ideas. In this kind of reaction, molecules receive energy in collisions, and after doing so remain in undisturbed isolation long enough for a considerable redistribution of energy to occur within them. The internal degrees of freedom of the molecule constitute its own energy reservoir from which, at the right moment, the amount necessary for the chemical transformation is drawn. The method by which this draft is made has, I think, a certain mystery about it, as will appear. The state of affairs described has long been represented by the following scheme :

$$\begin{matrix}\text{normal} \\ \text{molecules} \\ \text{(collisions)}\end{matrix} \quad \overset{1}{\underset{1'}{\rightleftharpoons}} \quad \text{activated molecules} \quad \xrightarrow{2} \quad \text{products} \qquad (1)$$

At low-enough pressures the rate-determining step must be the transfer of energy by collision, and at high-enough pressures this is replaced by the rate of transformation of the activated molecules, the rate constant k then attaining its limiting value. So far so good. But three major questions have excited attention, and are currently debated : First, what is the limiting value of k ? Secondly, does the above scheme adequately express the functional dependence of rate on pressure ? Thirdly, what exactly happens in the successive stages of the sequence depicted ?

The plausible assumption has usually been made that the decisive chemical act consists in the concentration of a critical energy, E, into one bond the rupture of which entails the transformation of the molecule. This hypothesis leads to the conclusion that the constant A is of the order of magnitude of a molecular vibration frequency, so that $k \sim \nu\exp(-E/RT)$, as follows roughly from general reasoning and in more detail from the exact calculations of Slater. The value of the entropy factor for the unimolecular reaction should be of the order 10^{13}, as indeed it sometimes is ; the utility of the naïve picture being thereby in a measure vindicated. But lately a continually growing number of examples have been found where it is significantly and even markedly higher.

Greater entropy of activation means less definition of the transition state, which is specified less and less accurately as the constant A increases beyond the value of about 10^{13}. If the unimolecular reaction occurs in solution, a large release of solvent molecules initially bound in a solvation complex could account for the increased entropy term ; but for a reaction in the gas phase the explanation must be sought elsewhere. When the entropy constant A is about the same as a bond vibration frequency it means, as has been said, concentration of energy into a single bond. If the very much greater values are to be believed, then much less restricted distributions must be admissible in the specification of the transition state. If every possible distribution of a total energy E among s degrees of freedom counted equally for this purpose, then the entropy factor ν would be multiplied by a combinatory factor,

$$\frac{(E/RT)^{s-1}}{(s-1)!} + \frac{(E/RT)^{s-2}}{(s-2)!} + \ldots + 1$$

which can assume magnitudes of several powers of ten, and easily explain all the experimental findings.

In the pyrolysis of paraffins, A has sometimes about the ideal value but in a good many examples is several powers of ten higher. The decomposition of di-*t*-butyl peroxide gives $10^{15.9}$. For a series of mercury dialkyls and mercury diphenyl, various observers have found values rising steadily with change in structure from 3×10^{13} to 10^{16}. For various thermal decompositions of compounds of the type R_2X with a relatively weak $R-X$ bond, factors ranging from 10^{14} to 10^{17} have been recorded (Clark and Pritchard). In the case of the mercury alkyl compounds the suggestion has been made that the high values are connected with a mechanism in which two Hg—R bonds are broken simultaneously. Hydrocarbon pyrolysis indeed involves the simultaneous rupture of a C—C bond and a C—H bond.

The steady accumulation of results gives increasing weight to the idea that chemical transformation is possible from a wider range of states than the simple theory supposed. This conception is not without its difficulties. When more than one degree of freedom is concerned in the activation process, it will not do merely to postulate a separately specified amount of energy in each. What is needed is a given sum total with no conditions about the sharing between them. Otherwise there would be no combinatory factor to magnify the entropy term. The theoretical implications of the pooled energy are highly significant.

This blurring of the definition of the transition state is the first elaboration of the simple pattern. New complexities are revealed by the fact that there are alternative fates for a decomposing molecule. Sometimes it yields only saturated molecular fragments and the transformation comes to an end. Sometimes it yields free radicals which initiate long

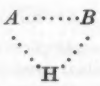
chains. Sometimes, however, it would seem, it may yield both.

In the search for simplicity we might well have expected the two mechanisms to be sharply separated, but evidence is accumulating that they are not. Moreover, although in a chain reaction an initial thermodynamic fluctuation is propagated, paradoxically this does not lead to a specially favourable entropy factor, as a simple calculation shows (Appendix 1). The high values of A previously referred to cannot be explained by chain reactions: nor have we any reason to say in advance whether the chain or the molecular mode should predominate. The rate constant of a chain reaction is a composite quantity representable as the product or quotient of unimolecular and bimolecular constants belonging to the various individual steps, and the order of magnitude of the overall entropy can easily be shown to equal in order of magnitude that of a single unimolecular or bimolecular reaction (or something in between). The length of the chain is governed essentially by the fact that the very large activation energy of the initial step appears in the final expression divided by a factor of two. Thus, a long chain reflects not a favourable entropy situation but a greatly lowered activation energy.

A reaction of the general chemical form

$$AB\mathrm{H} \longrightarrow A\mathrm{H} + B$$

often occurs by a chain mechanism in which initially a bond is ruptured with absorption of energy E_1. The effective activation energy of the whole process, however, works out at $\frac{1}{2}E_1 + \Delta$, where Δ is in general a much smaller term. The same reaction products may be formed by a molecular process through the transition state



without liberation of radicals. Although, unfortunately, the present resources of valency theory do not permit the calculation of the activation energy $E_{\mathrm{mol.}}$, this value is evidently much smaller than E_1, and whether $E_{\mathrm{mol.}}$ is greater than or less than $\frac{1}{2}E_1 + \Delta$ is a nicely balanced question.

Thus, neither entropy nor energy considerations decide clearly whether the chain mechanism or the molecular mechanism predominates, or whether both compete. (One general consideration operates in favour of the non-chain mechanism. At or below atmospheric pressure, $A_{\mathrm{uni.}}$ is greater than $A_{\mathrm{bi.}}$ in the ideal case. The common deviations of $A_{\mathrm{uni.}}$ are upwards by several powers of ten, while those of $A_{\mathrm{bi.}}$ are downwards. Since A_{chain} involves factors of the type $A_{\mathrm{bi.}}$, there is good chance that the entropy factor of the chain reaction may even be considerably less favourable than that of its molecular competitor.)

Corresponding to the ambiguous state of the theory, the experimental situation provokes some differences of opinion. It is, however, I think becoming increasingly difficult to do justice to the whole mass of facts without accepting the conclusion that in reactions such as the decomposition of paraffins or of ethers, chain reactions and molecular reactions do compete on more or less equal terms.

There are, then, alternative outcomes to the process of activation, and, as we have seen, there may be a sort of spectrum of activated states. Nor is this the end of the story. The final elaboration is provided by the facts about the dependence of rate constants on the pressure, whether of the reacting substance itself or of added foreign gases. In the scheme already given (scheme 1), the activation process (1,1′) is dependent on collisions, while the transformation of the activated molecules is spontaneous. The consequence is a gradual and continuous rise of the rate constant, k, with pressure from zero up to a constant limiting value. A change in the direction of the curve giving k as a function of pressure occurs where one rate-determining process supersedes the other.

Now the form of this curve has long been a subject of discussion, and appears to be a good deal less simple than was at first thought. In particular, certain examples show not one but two, or even three, changes of direction. These are most probably to be interpreted as indications of yet other potentially rate-determining steps in the whole train of events by which normal molecules are converted finally to products.

The piecing together of a complex mosaic of observations seems to suggest the following scheme:

$$\begin{matrix} 1 \\ \rightleftharpoons \\ 1' \end{matrix} \begin{matrix} \text{molecules with} \\ \text{sufficient store of} \\ \text{energy} \end{matrix} \begin{matrix} 2 \\ \rightleftharpoons \\ 2' \end{matrix} \begin{matrix} \text{critically} \\ \text{activated} \\ \text{molecules} \end{matrix} \begin{matrix} 3 \\ \longrightarrow \\ \end{matrix} \text{products} \qquad (2)$$

to which must be added a complete parallel sequence, corresponding at each stage except that in the end there emerge not saturated molecules but free radicals to propagate a chain reaction. (The evidence on which this view of things is based is given in Appendix 2.)

One factor which tends to unify the scheme, while at the same time providing for the striking apparent contrasts between individual examples, and yielding valuable experimental clues to what is happening, is the fact that every step of these sequences is subject to varying degrees of disturbance by the force fields of other molecules. In other words, communication of energy, redistributions of energy and the disruption of activated molecules are all specifically modifiable by collisions, with the result that the dependence of the rate on the pressure, whether of the reacting substance or of added foreign gases, is curiously complicated and puzzling, yet, it seems, always falls within the scope of the general mechanism outlined.

Do the rough fragments thus unearthed fit together into an intelligible design? This is a matter of opinion, but I think they do begin to do so.

The activated state is sometimes ill-defined in that a given total energy may be made up in many ways. Perhaps then this very fact makes more natural the occasional intervention of an extra step before the final crisis in the existence of the molecule. What this new step consists in is not at all certain. But suppose that the electrons of a bond uncouple to give the analogue of a triplet state. This process would not be describable by the crudely mechanical model of the primitive theories. It would occur when the total energy balance was correct and it would be sensitive to the perturbations of the fields of colliding molecules. The normally high energy of promotion to a true triplet state might be greatly reduced by compensating interactions between atoms in the bonds about to be formed.

According to this picture, the molecule in the last phase before decomposition would consist of radicals

held together by less than the normal chemical bonds. Whether these radicals escape from one another to initiate a chain or whether they satisfy their affinities by an internal shift of atoms becomes a delicately balanced matter, and largely an affair of total energy. Qualitative differences between the radical reaction and the molecular reaction would tend to vanish and the essential similarity of the two main sequences would be explained. The molecular reaction itself could be envisaged as a kind of internal chain reaction.

If these reflexions should prove to have any validity, the system would regain something of the symmetry it seemed to have lost. It would have indeed a less obvious kind of order, and one allowing room for much diversity of detail but within an essentially uniform framework.

The foregoing may have strayed rather far into the technical details of physical chemistry, but the theme itself required the reference to a set of facts in some confusion. Examples might be chosen from many other fields.

Subatomic physics had its primitive period when plausible interpretations of many important phenomena were provided by the simple idea of a nucleus containing protons and electrons. The simplicity has certainly vanished, and has been succeeded by the phase of complications and contradictions. But the third phase may well be at hand.

Many examples could be quoted from biology and indeed from outside the natural sciences. Men and angels are no longer separate creations, and neither statesman nor ecclesiastic, nor man of science either, dares maintain the crude simplicity of this antithesis. Yet their true relation is still far from clear. To find it is a major need.

Perhaps in these reflexions I have built too much upon some trivial observations, exaggerating their importance and over-straining the analogies which they suggest. But to reflect on the background, the setting and the general implications of the work we do is, I trust, consistent with the philosophical temper with which the Society began and which I like to think it will long preserve.

Appendix 1

A common type of chain can be represented by the general scheme :

$$ABH \xrightarrow{(n)} A + BH \qquad (1)$$

$$ABH + A \xrightarrow{(x)} AB + AH \qquad (2)$$

$$AB \xrightarrow{(y)} A + B \qquad (3)$$

$$A + AB \xrightarrow{(y)} ABA \qquad (4)$$

If steps (2) and (3) are repeated many times the net result is

$$ABH \rightarrow AH + B$$

with minute amounts of ABA from (4) and of H_2 from the decomposition of BH.

In the steady state

$$dx/dt = k_1 n - k_2 nx + k_3 y - k_4 xy = 0$$

$$dy/dt = k_2 nx - k_3 y - k_4 xy = 0$$

whence $$x = \frac{k_1 k_4 + (k_1^2 k_4^2 + 8k_1 k_2 k_3 k_4)^{1/2}}{4k_3 k_4}$$

If $k_2 k_3 \gg k_1 k_4$, as it must be for a long chain,

$$x \sim (k_1 k_2 k_3 k_4)^{1/2}/\sqrt{(2)}k_3 k_4$$

The reaction rate is $k_2 xn$, so that

$$k_{\text{chain}} n = \left(\frac{k_1 k_2 k_3}{2k_4}\right)^{1/2} n$$

k_1 and k_3 are characteristic of unimolecular reactions and may be written

$$k_1 = A_{\text{uni.}} \exp(-E_1/RT) \quad \text{and} \quad k_3 = A_{\text{uni.}} \exp(-E_3/RT)$$

A_1 and A_3 being assumed to have the standard value $A_{\text{uni.}}$

Similarly,

$$k_2 = A_{\text{bi.}} \exp(-E_2/RT), \quad k_4 = A_{\text{bi.}} \exp(-E_4/RT)$$

Thus

$$k_{\text{chain}} = A_{\text{chain}} \exp(-E_{\text{chain}}/RT) = \left(\frac{A_{\text{uni.}} A_{\text{bi.}} A_{\text{uni.}}}{2A_{\text{bi.}}}\right)^{1/2} \exp(-E_{\text{chain}}/RT)$$

where $$E_{\text{chain}} = \tfrac{1}{2}(E_1 + E_2 + E_3 - E_4)$$

and $$A_{\text{chain}} = A_{\text{uni.}}/\sqrt{2}$$

Apart from the trivial factor $1/\sqrt{2}$, the entropy factor of the chain reaction is therefore that of an ordinary non-chain unimolecular reaction.

The chain-length is given by k_{chain}/k_1. That it may be considerable is almost entirely due to the fact that $E_2 + E_3 - E_4$ is $\ll E_1$, so that the ratio is mainly determined by $\exp(-\frac{1}{2}E_1/RT)/\exp(-E_1/RT)$.

Similar results are found for calculations with other types of chain.

Appendix 2

In quite varied examples the curve representing k as a function of initial pressure shows more than one region where the change of slope indicates the replacement of one rate-determining process by another (pyrolysis of paraffins, decomposition of nitrous oxide). This can be accounted for by the introduction of the pair of processes 2 and 2′ of scheme 2. Furthermore, the variations of k with the pressure of the reacting gas or of added foreign gases are such that the best explanation seems to be provided by the assumption that the different gases intervene specifically and in varying degrees in processes 1, 2 or 3, according to the particular reaction. In the decomposition of ether, for example, the molecular reaction left after the suppression of chains is characterized by a value of k which exhibits an initial rapid rise with the pressure, either of the ether or of added hydrogen, and then a rapid reduction in the rate of increase as though a limit were being approached. No limit, however, is observed, but a steady and almost linear increase continues at a much slower rate over a wide range. In contrast with this, addition of many inert gases to the ether causes an initial increase in k to steady limits, well below values which can be reached by raising the pressure of the ether itself (G. R. Freeman). Similar phenomena are met with in the pyrolysis of paraffins, and in the decomposition of di-*t*-butyl peroxide (F. R. Birss). On the other hand, various foreign gases added to nitrous oxide give initial rapid increases in k followed by long-continued and slower rises of a nearly linear kind.

NEWS and VIEWS

Anthropology at the Australian National University: Prof. J. A. Barnes

PROF. J. A. Barnes has been appointed to the chair of anthropology in the Research School of Pacific Studies, formerly occupied by the late Prof. S. F. Nadel. Prof. Barnes, who will take up his new post in June, 1958, graduated from the University of Cambridge and received a doctorate of philosophy from the University of Oxford. In 1951 he was awarded the Wellcome Medal in Anthropology. Before going to Australia in 1956, to the chair of anthropology in the University of Sydney, Prof. Barnes had occupied posts as research officer with the Rhodes-Livingstone Institute; lecturer in the Department of Anthropology, University College, London; Fellow of St. John's College, Cambridge; Simon Research Fellow, University of Manchester; and reader in anthropology in the London School of Economics. Prof. Barnes' research has ranged widely, from the analysis of Ngoni social and political structure through the study of divorce rates in simple societies to a study of a Norwegian fishing parish. His book, "Politics in a Changing Society: A Political History of the Fort Jameson Ngoni", is both a historical study of an African people and a sociological analysis of changes in social structure. The Norwegian study makes use of the techniques of social anthropology in a sophisticated Western community.

British Internal Combustion Engine Research Association: Dr. W. P. Mansfield

DR. W. P. MANSFIELD has been appointed to the post of director of research of the British Internal Combustion Engine Research Association, Slough, with effect from March 1, 1958, in succession to Engineer Rear-Admiral D. J. Hoare, the first director of the Research Association, who is retiring. Dr. Mansfield, who is at present chief research engineer of the Association, graduated in engineering in the University of London in 1933. He was awarded the degree of Ph.D. in 1954 for his work on the scavenging process in two-stroke engines. He carried out research on gas and dual-fuel engines with the Erren Engineering Co. during 1934–37. In 1937 he joined Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., Slough, as research engineer, and was engaged in research and development of two-stroke engines. In 1944 Dr. Mansfield was appointed by the British Internal Combustion Engine Research Association to take charge of its research section.

National Science Foundation, Office of Scientific Information: Dr. B. W. Adkinson

DR. BURTON W. ADKINSON, director of the Reference Department of the Library of Congress, has been appointed head of the Office of Scientific Information of the National Science Foundation. His service with the Library of Congress began in 1945 when he was appointed assistant chief of its Map Division. He became head of the Map Division in 1947, and the following year assistant director of the Reference Department. Before going to the Library of Congress, Dr. Adkinson was assistant chief, Map Intelligence Section, Office of Strategic Services, during 1944–45; research associate and later assistant director of the Board of Geographic Names, during 1943–44; and regional research assistant in the Office of the Geographer, during 1942–43. Prior to his association with the United States Government, he lectured in geography at the University of Washington, and earlier, in climatology at Clark University. He was a teacher in the public schools of Washington State during 1929–39. Dr. Adkinson is a graduate of the University of Washington, and received the degree of Ph.D. in geography from Clark University in 1942. He is the author of papers in fields of geography, glaciology and cartography.

Royal Society: Officers

AT the anniversary meeting of the Royal Society on November 30, Sir Cyril Hinshelwood was re-elected president. Prof. W. V. D. Hodge, Lowndean professor of astronomy and geometry in the University of Cambridge, was elected physical secretary in succession to Sir David Brunt. The other officers re-elected for the ensuing year were: *Treasurer*, Sir William Penney, director of the Atomic Weapons Research Establishment, Aldermaston; *Biological Secretary*, Sir Lindor Brown, Jodrell professor of physiology at University College, London; and *Foreign Secretary*, Dr. H. G. Thornton, lately head of the Department of Soil Microbiology at Rothamsted Experimental Station. Other members of Council elected were: Brigadier J. S. K. Boyd, lately director of the Wellcome Laboratories of Tropical Medicine; Dr. G. E. R. Deacon, director of the National Institute of Oceanography, Wormley; Sir Charles Dodds, Courtauld professor of biochemistry, University of London; Prof. N. Feather, professor of natural philosophy, University of Edinburgh; Prof. G. Gee, Sir Samuel Hall professor of chemistry, University of Manchester; Dr. H. Godwin, reader in quaternary research, University of Cambridge; Prof. R. D. Haworth, Firth professor of chemistry, University of Sheffield; Sir Bryan Matthews, professor of physiology, University of Cambridge; Prof. W. T. J. Morgan, deputy director of the Lister Institute and professor of biochemistry in the University of London; Prof. D. M. Newitt, Courtauld professor of chemical engineering, Imperial College of Science and Technology; Prof. A. C. Offord, professor of mathematics at Birkbeck College, University of London; Prof. R. E. Peierls, professor of mathematical physics, University of Birmingham; Prof. L. Rosenhead, professor of applied mathematics, University of Liverpool; Lord Rothschild, assistant director of research, Department of Zoology, University of Cambridge; Dr. K. M. Smith, director of the Virus Research Unit (Agricultural Research Council), Molteno Institute, University of Cambridge; Prof. L. R. Wager, professor of geology, University of Oxford.

Scientific and Industrial Research in Britain

SEVERAL questions about scientific and industrial research have been asked in the House of Commons in recent weeks. Replying to Sir Wavell Wakefield, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that solar radiation is not at present being used in Britain to produce high temperatures for research purposes. Replying to a question from Mr. A. Allen regarding arrangements being made to increase the availability of translations of Russian scientific papers and books, Mr. Nicholls

said that the Department of Scientific and Industrial Research has started a comprehensive collection of translations of Russian scientific and technological literature in all fields, except clinical medicine. This material is being made available through the Department's Lending Library Unit, which also lends Russian technical literature to research organizations, industrial organizations, universities and colleges and Government departments. Microfilms of several thousand translations of Russian scientific papers have also been ordered from a library in the United States. In conjunction with the Scientific Library and Technical Information Committee of the Advisory Council on Scientific Policy, the Department is considering what additional measures are required to improve the volume of translations of Russian scientific papers and books being undertaken in the English-speaking world.

In answer to further questions, Mr. Nicholls said that the Department has undertaken to consider proposals for contracts designed to promote developments of particular ideas or in particular industries, in the public interest, when these are outside the scope of, or unacceptable to, the National Research Development Corporation. The suggestion in the last annual report of the Advisory Council on Scientific Policy that British firms might make arrangements to interview British scientists and engineers in North America has been referred for consideration to the appropriate committees of the Federation of British Industries, and the Department of Scientific and Industrial Research is considering what action could be taken to encourage more British scientists and engineers to undertake postgraduate work in Europe.

Progress in Technical Education

Answering questions in the House of Commons about technical education on November 28, Mr. Geoffrey Lloyd, Minister of Education, said that since the publication of the White Paper in February 1956, eighteen new technical colleges and seventy-nine major extensions of existing colleges have been started. In addition, final plans for five more new colleges and seventeen further major extensions with a total value of £5 million have been approved, and sketch plans prepared for a further fourteen new colleges and twenty-eight major extensions, to the value of more than £8 million. There were 31,700 part-time day students of higher technology in Britain in 1955–56.

Nigerian Geographical Journal

It is a sign of geographical progress that the geography of regions that were literally being explored by Europeans only two or three generations since is now being written from the inside. Europeans and Americans may still write books entitled "Africa" and they will still have value because of their external and comparative points of view. But a day must come when the geography of Africa is written from within, and of that day the first number of *The Nigerian Geographical Journal* is a harbinger (1, No. 1; April 1957. Pp. iv+20. Per volume of two numbers, 15*s*. Ibadan: University College, 1957). Its first function is to be a means of communication, giving the members of the two-year-old Nigerian Geographical Association—still fewer than a hundred all told and scattered over a vast territory—a sense of community and common endeavour. Its second is to afford a means of self-expression for Nigerian geography. Of the articles in this issue the first is, understandably enough, the text of an address given by Prof. B. J. Garnier, of the Department of Geography, University College, Ibadan, to the members of the Association on the importance of their subject. Another, by a Nigerian teacher in a Government secondary school, says some homely and helpful things about geography teaching to his fellow-teachers. Of more interest and significance, however, are two articles that describe parts of Nigeria. The longer and more sophisticated of these is from the sympathetic pen of the vice-principal of the Government Teacher Training College, Ibadan; the shorter is a description of his home district by a Nigerian undergraduate. Here is the beginning of an African geography written by those who alone can truly understand the human element in the man–land equation in Africa.

British Museum (Natural History)

Among the more important recent acquisitions to the British Museum (Natural History) is a gift by Mrs. P. Harwood of the very fine collection of British insects amassed by the late Philip Harwood, formerly of Kincraig, Inverness-shire, and latterly of Wimborne, Dorset, during a life-time devoted to specialized collecting. In addition to his own collecting there are many specimens from the collections of his father and his brother. It was Mr. Harwood's special wish that the Hymenoptera and the Hemiptera should go to the British Museum and the remainder to the University Museum, Oxford. The collection has not yet been counted, but it is estimated that it contains many thousands of specimens, including some of very rare and valuable species which will fill long-vacant gaps in the Museum's collections, and many individuals on which were based the first records of the occurrence in the British Isles of the species concerned.

The Botanic Gardens, Singapore

An encouraging account of the work done at the Botanic Gardens, Singapore, during 1956 has been prepared by the former director, J. W. Purseglove. Besides the usual meteorological records and the extensive activities connected with the herbarium, the staff made many contributions to botanical knowledge through collections and research. One marine green alga, collected at Mersing, was found to be *Acetabularia crenulata*, a new record for Malaysia. Considerable horticultural work was also carried out despite depredations by monkeys and human beings. The former learned to respect the electric fence which was put up around the orchid enclosure; but this did not prevent intrusions by human beings. As a result of thefts it is no longer possible to display valuable orchids in the plant house. The staff continued to advise many schools and other government institutions during the year. Copies of this interesting report may be obtained from the Government Publications Bureau, G.P.O., Fullerton Buildings, Singapore, price 1.50 dollars.

Root Nodules of *Casuarina*

G. Bond has reported that young plants of *Casuarina cunninghamiana* and *C. equisetifolia*, growing in water culture, developed macroscopic nodules in 26–35 days from inoculation, the nodulation being most successful at *p*H near neutrality and falling off much more rapidly at lower *p*H than

in other non-legume nodule-forming genera. The distinctiveness of the *Casuarina* organism is thus confirmed. The roots springing from the nodule lobes are shown to be characterized by upward growth and in this to resemble remarkably closely the corresponding roots of *Myrica*. Nodulated plants of *Casuarina* are able to grow vigorously in culture solutions free of combined nitrogen, showing that fixation of atmospheric nitrogen occurs, amounting in *C. cunninghamiana* to 50 mgm. per plant during six months of active growth. The evidence indicates that the fixation occurs in the nodules, and that these have exactly the same functional significance as those of legumes (*Ann. Bot.*, N.S., 21, 373; 1957).

Annual Variation of Sporadic Meteors

In a paper on the theory of the annual variation of sporadic meteors (*Pub. Astron. Soc. Japan*, 8, Nos. 3–4; 1956), Tadayoshi Murakami, of the University of Hiroshima, explains that his reduction of the annual variation was undertaken to verify his drift motion hypothesis of interstellar meteoric particles, published under the title "On the Drift Motion of the Interstellar Meteors in the Vicinity of the Solar System" (*Mem. Oriental Astron. Assoc.*, No. 152; 1954). In the present paper the author admits that most of the meteoric particles for sporadic meteors move together with the solar system, the variation being governed mainly by the altitude of the apex of the Earth's way. A comparison between the meteor rate deduced from observation and the altitude of the meteor apex shows that the relation is simple, and a theory is developed to explain this fact. While admitting that there is a discrepancy between theory and observation, it is pointed out that this can be ascribed to the irregular distribution of the density of the meteoric particles. The relation between the number of meteors m_e and the zenith distance of the meteor apex can be expressed by the empirical formula $m_e = 12{\cdot}6 \cos \zeta + 6{\cdot}3$, where $76° < \zeta < 104°$. The number of meteors calculated from this formula shows a satisfactory agreement between the observed and calculated variations (*Pub. Astron. Soc. Japan*, 8, 87; 1956). Although the true distribution of meteors is very different from uniform, as shown by the work of Lovell, Prentice, Hawkins and Aspinall, the author contends that, for a first approximation, uniformity of distribution must be postulated, irregularities of distribution being considered in the next step. On this assumption he derives a formula similar to that derived by Davidson (*J. Brit. Astron. Assoc.*, 24, 352; 1914). The value of the heliocentric velocity obtained is 58·5 km./sec., which does not agree with modern determinations of meteor velocities. It is admitted that the subject requires further consideration but the results suggest that there is unevenness of density distribution of meteoric particles.

University News: Exeter

The following appointments in the University of Exeter have recently been made: Mr. A. Stuart, to the newly created chair of geology; Dr. K. E. Grew, to be reader in physics; G. A. Duller, as assistant lecturer in mathematics; Dr. H. P. Mulholland, as senior lecturer in mathematics; D. J. Stone, as lecturer in mathematical statistics; Dr. R. J. Williams, as lecturer in physical chemistry.

Announcements

Sir Solly Zuckerman, Sands Cox professor of anatomy in the University of Birmingham, has been awarded the Cross of Chevalier in the French national order of the Légion d'Honneur.

The Castner Gold Medal of the Society of Chemical Industry has been awarded for 1958 to Dr. R. Holroyd, deputy chairman of Imperial Chemical Industries, Ltd. The Medal was instituted to commemorate the work of Hamilton Young Castner and is one of the Society's senior awards. It is awarded every two years.

Trinity College, Cambridge, offers entrance exhibitions to male students of universities in the British Commonwealth to enable them to read for the degree of B.A. or LL.B., or for a diploma. Further information can be obtained from the Senior Tutor, Trinity College, Cambridge.

The *New Zealand Journal of Science and Technology* is to be replaced at the beginning of 1958 by the *New Zealand Journal of Agricultural Research* (bi-monthly), the *New Zealand Journal of Geology and Geophysics* and the *New Zealand Journal of Science* (both quarterly).

An exhibition of laboratory apparatus and techniques will be held in the College of Science and Technology, Sackville Street, Manchester, on December 18, during 2–8 p.m., and on December 19 during 10 a.m.–8 p.m.

A half-day conference on "Production Control", organized by the Industrial Applications Section of the Royal Statistical Society, will be held on December 13 at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1. The conference starts at 2 p.m. Further information can be obtained from A. N. James, Wynyates, Church Road, Watford, Herts.

The Institute of Physics has arranged a three-day conference on "Nuclear Fuel Cycles", to be held at the Institution of Civil Engineers during January 15–17, 1958. Further details can be obtained from the Institute of Physics, 47 Belgrave Square, London, S.W.1.

The 128th course of six Christmas lectures "adapted to a juvenile auditory" is to be delivered at the Royal Institution on December 28 and 31, 1957, and January 2, 4, 7 and 9, 1958, at 3 p.m., by Dr. Julian S. Huxley and Mr. James Fisher on the subject of "Birds". The lectures will deal with "Birds in the Animal Kingdom", "Birds and Flight", "Birds Past and Present", "Birds Rare and Common", "Bird Migration and Navigation", "Bird Watching". The first lecture will be given by Dr. Huxley and the remaining five by Mr. Fisher. Applications for tickets (juveniles, aged 10–17, £1; adult non-members, £2) should be addressed to the Royal Institution, 21 Albemarle Street, London, W.1.

Erratum. We regret to find that mistakes have occurred in numbering the axes of the graph which accompanied the communication entitled "Vitamin B_{12} in Marine Ecology" by M. R. Droop, in *Nature* of November 16, p. 1041. The ordinate graduations (number of cells per ml.) should be 10^5, 10^6 and 10^7 (reading upwards); the abscissa graduations (vitamin B_{12} ($\mu\mu$gm./ml.)) should be 0·1, 1·0 and 10 (reading left to right) and these numbers should appear immediately below the marks on the horizontal axis.

THE POST OFFICE RESEARCH STATION

THE Post Office Engineering Research Station at Dollis Hill held an open day on September 27, when several hundred visitors from the universities, industry and Government departments were able to see some of the work in progress or recently completed. Some exhibits were of exploratory work, but most were of new apparatus or systems. The contributions made by the Station to several notable developments in telecommunications since the last open day (in 1954) were reflected in the exhibits; only that to the development of electronic telephone exchanges, now being undertaken jointly with industry, was not given prominence.

Submarine telephony was represented by several diverse exhibits, including some of the equipment and techniques used for the first trans-Atlantic telephone cable which had celebrated the first anniversary of the opening of its service a day or so earlier; others were intended for future use. A length of the new light-weight deep-sea cable proposed by the Post Office was exhibited; its cross-section is shown in Fig. 1. The placing of the strength members inside the inner conductor reduces the size and cost of the cable and renders it nearly kinkless. A full-scale deep-sea trial is planned. The technique developed for jointing lengths, by swaging a steel ferrule over the steel strands, retains at least 94 per cent of the intrinsic strength of the cable. Only one repeatered submarine cable is necessary for a system designed by the British Post Office, because the amplifier is so associated with directional filters as to be able to amplify sixty conversations in each direction simultaneously. The complete repeater is bulky and rigid, however, and its laying has hitherto presented difficulties; it cannot be passed over or around the normal laying drums. A method of laying is being developed, in which the repeater by-passes new cable-laying equipment; it will not require the ship to be stopped. It was demonstrated by a scale model in the new hydraulics laboratory, where visitors could see also the large pressure vessels and machinery for testing repeaters and their glands at pressures up to the highest reached on the ocean bed, 6 tons/sq. in. The plant for making the glands which seal the repeater against the ingress of water at such high pressures, and the portable low-voltage X-ray apparatus for inspecting joints and glands were on show. The Station has long undertaken the supply of thermionic valves for submerged repeaters and has recently completed the design of a new valve, which is, mechanically at least, a big advance on earlier types. The heater, a wire helix of rectangular cross-section and electrically double-ended, fits inside a tube of sintered alumina which in turn fits closely inside the platinum core of the cathode. The design of the other electrodes had to take account of the restricted anode and screen grid voltages imposed by the need to limit the overall voltage which has to be applied to the ends of the cable—the repeaters are fed in series from the ends—and had to prevent ions formed in the anode/screen grid space from reaching and damaging the cathode. Only very little mica is used in the valve.

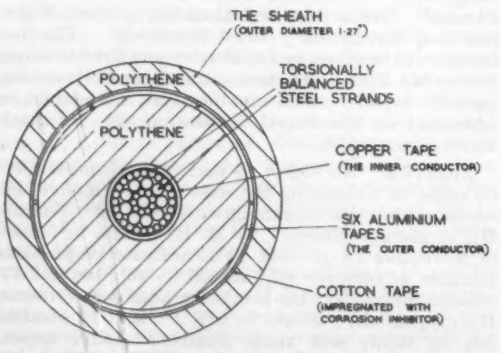


Fig. 1. Cross-section of proposed light-weight deep-sea cable

Work has continued on techniques and equipment for radio communications using frequencies around 4,000 Mc./s. Frequency control has been obtained by extending conventional multiplication to micro-wave frequencies; the starting point is an oscillator with quartz resonator, operating at about 50 Mc./s., and the higher intermediate stages use cavity resonators and triode valves with very close electrode spacings. Long-term stability is better than one part in 10^8 and short-term better than one part in 10^9. For work involving measurements over the band 3,800–4,200 Mc./s. a method of launching signals, aperiodically, at the short-circuited end of a wave-guide has eliminated all controls except that of the frequency of the test oscillator. The joining together of wave-guides of different rectangular cross-sections has been improved by the use of symmetrically stepped transforming sections. A rapid method of measuring the voltage standing-wave ratio in wave-guide, using a rotating loop, was demonstrated; the ratio can be displayed as a function of frequency over a width of band up to 50 Mc./s. A new modulator, electrically balanced but using only one non-linear element, has been developed for frequency changing between the intermediate (70 Mc./s.) and micro-wave frequencies.

The Post Office uses correction by artificial echoes on long-distance television links to reduce the linear wave-form distortions which are not removable by conventional equalization. The standard echo wave-form corrector combines the input signal with an adjustable array of advanced and retarded echoes over a range of 3 microseconds. A new corrector uses doublet, or differentiated, echoes in a novel circuit which enables the range to be extended to suit the requirements for individual links. A unit-block construction provides for extensions in steps of 2 micro-seconds. The cost and size are much less than those of the standard model. Fig. 2 shows the response, of a 200-mile cable link, to a pulse (sine-squared in shape and of duration one-third microsecond at half amplitude) before and after echo correction.

Big savings have been obtained in the United States by converting amplified loaded cables from four-wire to two-wire working—thereby doubling the traffic handling capacity—following the development of negative-impedance, valve amplifiers having only

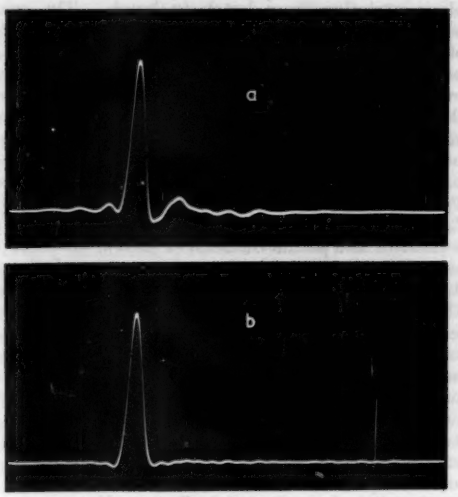


Fig. 2. Response of 200-mile cable link to 1/3-μsec. sine-squared pulse: (*a*) as received; (*b*) after echo-correction

two terminals. But the reduction of attenuation obtained by the insertion of one negative impedor, whether in series or in shunt with the conductors, introduces a serious mismatch and hence loud echoes. If two are inserted at the same point, one in series and one in shunt, and are suitably related to one another and to the cable impedance, echoes can be very much reduced. Such a pair of elements, each using one transistor, have been designed and models are undergoing field trials.

Radio-telegraphy over long distances is being studied in order to minimize the errors in the received messages which arise due to fading, noise and interference. Current practice uses frequency-shift telegraphy, the demodulator in the receiver having a limiter and frequency discriminator; errors arise if signals on either the frequency of the 'space' or that of the 'mark' fade into the noise. The complete message is, however, available on each frequency separately and an improved method of demodulation has been developed which fails only if the signals on both frequencies are simultaneously seriously affected by noise—a rare event because fading is usually frequency selective. Both this study and work on more conventional systems were facilitated by two new equipments, an automatic counter of errors and a fading machine which gives a close approximation to natural fading by combining six signal components in substantially random phase.

Among the larger exhibits was a letter-facing machine, to which attention has been particularly directed since the completion of the design of a letter-sorting machine now going into production. The postal mechanization laboratories were showing also a method of classifying information based on the keying of the first few letters of, say, the name of a town.

Some features of speech interpolation were demonstrated on equipment being built to enable technical studies to be made. The idea uses the fact that at no time during a telephone conversation need both a 'go' and a 'return' channel be provided. If a group on n trunks is available, it may sustain m conversations ($m > n$) without detriment to the conversations, provided terminal equipment can allocate free one-way trunks to speakers the moment they are needed. A practical equipment may need to be complex, but even so it may be economic if, for example, it can effectively double the capacity of a long oversea trunk route.

A sound spectrograph developed for the study of speech transmission systems based on formant coding is capable of analysing any audio-frequency signals. It indicates on 'Teledeltos' paper the energy contained in the recorded signal being analysed in the frequency band $f - \frac{1}{2}\Delta f$ to $f + \frac{1}{2}\Delta f$, where Δf can be selected between 20 and 500 c./s. and f is scanned from zero to a maximum value of 5 kc./s. The level range has been extended, from the 8 db. obtainable with the conventional constant-current excitation of the stylus which marks the paper, to 40 db. by the use of width-modulated pulses of constant amplitude. Among other new apparatus for laboratory use was one for measuring the thickness of tarnish films to within 10 A.

The prize-winning numbers of Premium Savings Bonds are produced by apparatus 'ERNIE' designed at the Station. The key elements, the generators of random digits, are duplicated and their outputs so combined that failure of one does not upset the randomness of the sequences produced. Several electrical and statistical tests are used for checking the randomness. One of the statistical analyses uses some of the conventional tests for randomness, namely, frequency (of individual digits), serial (the frequency of pairs of digits), gap (intervals between successive appearances of the same digit), poker (classification of blocks of four as 'all alike', 'all different', etc.), and coupon collector (size of block containing at least one of each digit). The analysis is carried out automatically on the Pegasus electronic digital computer, the input tapes for the computer being produced automatically (in the Pegasus code) by auxiliary equipment.

A new rolling mill, coupled with the application of powder metallurgy to nickel iron alloys and with closely controlled annealing schedules, has made possible very thin magnetic tapes of consistently high permeability (for example, 40,000). The two work rolls of the four high mill are less than $\frac{1}{2}$ in. in diameter and are supported along their entire lengths; the plane containing their axes is inclined to that containing the axes of the backing rolls. After the final roll, which may be to a thickness as little as 0·0002 in., the tape is slit in another new machine which uses a flexible disk the cutting edge of which is so shaped and deflected as to provide correct cutting clearances.

The Station has of recent years supplied further quartz resonators to many of the leading observatories of the world. A new resonator—a short bar approximately square in cross-section, with a volume of about 2 c.c. and vibrating torsionally—is under development. It may prove an alternative to the Essen ring, compared with which it is more robust and easier to make; but it has yet to be shown to have quite as high a stability.

Several exhibits dealt with the technology of germanium and components made from it. Sections of junction transistors made by alloying indium to the two faces of a thin wafer showed the accurately plane and parallel junctions obtained when sufficient care is paid to crystal orientation, wetting of the ger-

manium by the indium, alloying and cooling. The kinetics of the gas-phase erosion of germanium are being studied by observations of changes of pressure and weight. Fast junction diodes are being made by heavily doping the germanium with nickel; their performance was demonstrated.

Collectively, the exhibits showed three broad features of progress in telecommunications. First, an increasingly large part is played by electronic engineering, backed by improved materials and new components. Secondly, the role of mechanical engineering is changing as fewer new components have moving parts or require fine clearances; it may lie rather in the machines making the components or assembling them. Thirdly, reliability has to be studied more intensively than ever before, and in good time, if applications of new scientific discoveries are to be successful.

COLOURS AND FLAVOURS

THE first of a series of four meetings under the general title of "Some Nutritional and Allied Problems confronting the Food Manufacturers", arranged by the Nutrition Panel of the Food Group of the Society of Chemical Industry, was held in the Society's rooms at Belgrave Square, London, on October 23. These meetings are concerned with food additives, the first dealing with "Colours and Flavours" and the subsequent ones with "Antioxidants", "Emulsifying and Dispersing Agents" and "Chemical Preservatives". Interest in food additives has increased considerably since the end of the War, especially in view of pending legislation in this field, and the first meeting was very well attended.

The first paper at this meeting, under the chairmanship of Dr. F. Aylward (Borough Polytechnic), was read by Dr. B. R. J. Thomas, of A. Boake, Roberts and Co., Ltd., on the "Technological Aspects of Colourings". Dr. Thomas pointed out that the arguments for the use of colours in food were well known and well founded and were accepted by all authorities. The main object of his talk was to deal with the present British list of permitted colours, indicating the problems it raised for the food colour supplier and the food manufacturer. In view of the importance of appearance in the selection and appreciation of a food, the manufacturer is anxious to obtain the right shade for a particular use to which a colour is put, although public taste can be schooled to accept minor departures from previous standards. From the point of view of cost, colour is not an important item to the manufacturer as long as he has not to change it frequently. Thus, speaking in approximate terms, 1 lb. of amaranth will colour 2,000 gallons of raspberryade or 4,000 gallons of ice cream. This means that the cost of colouring raspberryade is approximately 0·09*d*. per gallon or 0·045*d*. per gallon of ice cream, assuming a price of 15*s*. per lb. for the dye.

The desirable properties of an ideal colour were then enumerated. Such a colour must be without suspicion of carcinogenic activity and must be obtainable in a pure form free from carcinogenic impurities. It must also be stable to a temperature range of − 10° to 100° C., and also to *p*H's of 2–8 and to light during storage. It should be resistant to oxidation and reduction and to preservatives, especially sulphur dioxide, and there should be no colour variation from batch to batch. The colour should also be obtainable in oil-soluble and water-soluble forms. On the basis of the above properties, the British list[1] was examined, the discussion being confined mainly to the so-called *A* colours (colours which, from the available evidence, would seem unlikely to be harmful when consumed in foods in the customary amounts) and vegetable extracts.

Reds. The British list[1] contains seven red *A* colours (Ponceau 4*R*, Carmoisine, Amaranth, Red 6*B*, Red *F.B.*, Ponceau *SX* and Fast Red *E*) which conform to most of the points mentioned above, although not one of them is oil-soluble and not one of them is absolutely satisfactory from all points of view. Rhodamine *B*, and Erythrosine of seaside rock and canned cherry fame, are now classified as *C* and *B* colours, respectively, yet for the specific purposes mentioned they are irreplaceable. (*B* colours are those for which the available evidence is deficient or conflicting although there is no apparent reason on structural or other grounds to expect them to be harmful in the amounts ordinarily consumed. *C* colours are those which have been shown, or are suspected, to have harmful effects.) Not one orange colour has been given an *A* rating, and this means that the manufacturer has to use a blend of other *A* colours, which at once raises all kinds of difficulties as a result of the differing stabilities of the constituent colours of the blend. The absence of satisfactory red and orange oil-soluble colours is a serious limitation in the coloration of dairy products and frying oils.

Yellows. The three *A* colours, Tartrazine, Naphthol Yellow *S* and Sunset Yellow *F.C.F.*, cover most of the needs of the colour user, but the alkali stability of these water-soluble dyes is not high enough for all applications. Again, there are no oil-soluble yellows in the *A* list.

Green and blue. The British list[1] is very deficient in these colours, two blues only, Indigotin and Blue *V.R.S.*, being available. The former is very unstable, and when green is needed the manufacturer is reduced to the unsatisfactory course of using blends of other dyes. Of blacks, there are no *A* colours, but Black *B.N.* is on the permitted list as a *B* colour, although Black *B.N.*, has a definite blue tinge, which is a disadvantage.

After reviewing the British list[1], Dr. Thomas suggested that an intensive study is needed of higher wave-length colours both from the point of view of use and of carcinogenicity. Furthermore, he pointed out that the British list differed from those of other countries, and this raised difficulties if a food manufacturer wanted to export. Thus, Naphthol Yellow *S* was on the British list but not on the American list, while Britain and Australia were the only countries which permitted Blue *V.R.S.* Light Green *S.F.* Yellowish was permitted in the majority of countries except Britain. There was therefore a strong argument for some international agreement upon colours permitted as food additives.

A reference was made to vegetable colours which may find increasing use in the future in view of the dearth of synthetic oil-soluble colours. These colours are difficult to produce and standardize. There are ten vegetable extracts in the British list[1], but apparently only five of these appear in the lists of other countries.

Mr. G. R. A. Short, of W. J. Bush and Co., Ltd., spoke about the "Technological Aspects of Flavour-

ing", and introduced his subject with a brief mention of the important function of added flavours to make food more attractive and to create a desire for more. Knowledge of added flavours is very old. Cassia bark is mentioned as far back as 2700 B.C. and cloves from 266 B.C. onwards by the Chinese, who eat otherwise monotonous rich dishes. Wood smoke for fish and meat is also a very old practice.

When a food processer decides on a new flavour, he has many problems to solve. For clear beverages or table jellies a soluble essence is needed; for cloudy beverages an emulsion flavour will be best. In sugar confectionery work, fondants and chocolate centres, a delicate essence in a volatile solvent is needed, while for boiled sugars there is need of a more powerful essence in a high-boiling solvent. Whether a natural or a synthetic flavour is to be used depends on cost, for natural fruit flavours are of low flavouring value, difficult to standardize and are needed in large quantities. The use of a fruit juice concentrate in a table jelly crystal would not be satisfactory since it would produce an unsaleable sticky mass. Synthetic flavours, however, are obtainable in a pure state which maintain the strength and quality of the flavours they contain. To-day many moderately priced essences are blends of natural and synthetic ingredients. There are also the problems of public taste; one peculiar difficulty facing the flavour industry is to decide whether public taste favours the flavour of fresh fruit or of the cooked variety. Thus the public is more familiar with the flavour of cooked than fresh raspberries, and it often demands a flavour remote from that of the natural product, such as amyl acetate as the major constituent of pear-drop flavour.

Natural flavours are extremely complicated. Thus, raspberry juice has been found to contain acetic, *n*-caproic and benzoic acids, ethyl, phenethyl and benzyl alcohols, benzaldehyde, diacetyl, ethyl acetate, γ-methyl-*n*-butanol, and many other unidentified substances, including lactones, phenols, aldehydes, ketones and acids. The number of constituents contributing to the aroma of coffee is as many as seventy and include hydrogen sulphide, methyl and furfuryl mercaptans, dimethyl sulphide, acetaldehyde, furfural, methyl-furfural, vinyl guaiacol, methylpyrrole, etc.

The flavour chemist has at his disposal, in addition to natural extracts and essential oils, a very wide range of synthetic materials which include alcohols, acids, esters, aldehydes, phenols, phenolic ethers, ketones and lactones. The flavour value of most of these synthetics is so great that less than one to three hundred parts per million are necessary to flavour food or beverages. Thus, only 5–6 parts per million of diacetyl added to a fat are needed to impart a flavour similar in strength to that of butter. So far, very few of the flavours have been found to be harmful, but we still know very little about the effects of flavouring materials on the human organism.

Prof. R. T. Williams (St. Mary's Hospital Medical School) then discussed the biochemical and pharmacological aspects of colours and flavours. It was pointed out that some of these additives were potentially toxic and in some cases carcinogenic. There was no doubt that, in the future, colours and flavours would be subject to close scrutiny from a biochemical, toxicological or pharmacological point of view.

Ideally the information needed before a substance could be used as a food additive would consist of data concerning acute and chronic toxicity, carcinogenicity, absorption from the alimentary tract, biochemical transformations and the toxicity of metabolites, elimination from the body and accumulation in the body. Much time and labour will be involved in obtaining this information; and therefore, in deciding on the suitability of a substance as a food additive, attention should also be paid to past experience, a general knowledge of metabolism and common sense so that decisions are not too long delayed.

From a structural point of view, most of the permitted food colours are sulphonic acids and azo compounds. Sulphonic acids are usually strong acids, and strong acids are either not absorbed from the intestine, or if they are absorbed then they tend to be rapidly excreted in the urine. It would therefore be of advantage if a food additive were a water-soluble strong electrolyte, since it would tend to be rapidly eliminated. However, dyes are complicated molecules, and it would be an over-simplification to regard them simply as strong acids.

Some azo dyes have been shown to be carcinogenic, and this effect can be due either to the dye molecule *per se* as in the case of butter yellow or because it gives rise to carcinogenic metabolites. Azo compounds are potentially capable of being split enzymically in the body into two amines, and any azo compound (for example, 2-naphthylazo dyes) potentially capable of giving rise to β-naphthylamine, a known carcinogen, is to be suspect[2,3]. On the other hand, 1-naphthylazo dyes have not been regarded with as much suspicion as 2-naphthylazo dyes, because the carcinogenicity of α-naphthylamine is in doubt. Sunset Yellow *F.C.F.*, Amaranth and Ponceau 4*R* are examples of 1-naphthylazo dyes which have an *A* classification. It is to be noted that these dyes contain sulphonated ring systems on both sides of the azo link. Ponceau *MX* is also a 1-naphthylazo dye, but it is sulphonated only on one side of the azo link and presumably this is why it has a *B* classification. Some oil-soluble dyes have a *C* classification because they are cathartics[4], for example, Oil Yellows *AB* and *OB*, Oil Oranges *TX* and *XX*.

Most synthetic flavouring agents appear to be compounds of low toxicity, and since they are used in minute quantities little apparent harm is likely to follow from their use. Prof. Williams showed with a series of slides that the body has detoxication mechanisms for dealing with the esters of aliphatic and aromatic alcohols with fatty acids, alcohols, aldehydes, phenols, ketones and acids which are used as flavouring agents. However, this is no reason for not being on the alert for potential toxic agents among flavouring material. Thus, coumarin is a flavouring agent which has recently fallen into disrepute and is no longer used in the food flavouring industry, since feeding experiments on animals have shown that it produces liver damage[5]. Some doubts have also been expressed about citral since it may act as a retinene competitor[6]; but in this case a thorough investigation of its biological properties is needed.

In the discussion which followed, Mr. A. L. Bacharach commented on Prof. Williams's suggestions regarding the general tests which might be needed to pronounce a food additive as safe. It may not be necessary always to carry out all the tests on every substance investigated. By arranging them in suitable order, one test can be made to act as a

'screen' for the next. Furthermore, studies on absorption, metabolism and excretion should be directed more towards substances which appear to do no harm rather than those showing toxic effects, since the former are the ones which might find industrial uses. The question of whether the examination of food additives by isolated enzyme systems would yield useful information was put by Dr. A. Bender. It was agreed by Prof. Williams that useful information could be obtained in this way if care were taken in the interpretation of the results. Since a food additive is usually taken by mouth, it may not be absorbed, and if it is absorbed it does not necessarily follow that it will reach the location in the body where a particular enzyme is found. It is thus possible with foreign compounds that *in vitro* experiments will not always yield the same results as *in vivo* experiments. *In vivo* experiments are considerably more important with foreign compounds than with the body's natural metabolites, which are now largely studied in *in vitro* systems.

The possibility of reproducing natural flavours was also discussed by Dr. V. L. S. Charley (Carters). Since lists of organic compounds that have been found in fruit juices had been recorded in the literature, could not a true flavour be made from a blend of the compounds given in these lists ? According to Mr. Short, experience had shown that mixtures of the constituents reported do not reproduce the true flavour of fruit for the reasons that some constituents remain unidentified, while others, particularly aromatic compounds, decompose during extraction.

R. T. Williams

[1] Food Standards Committee Report on Colouring Matters, Ministry of Agriculture, Fisheries and Food (H.M. Stationery Office, 1954; Supplementary Report (1955)).

[2] See Badger, G. M., *Brit. J. Cancer*, **10**, 330 (1956).

[3] See Bonser, G. M., Clayson, D. B., and Jull, J. W., *Brit. J. Cancer*, **10**, 653 (1956).

[4] Vos, B. J., Radomski, J. L., and Fuyat, H. N., *Fed. Proc.*, **12**, No. 1243 (1953). Radomski, J. L., and Deichman, W. B., *J. Pharmacol.*, **118**, 322 (1956).

[5] Hazleton, J. W., Tusing, T. W., Zeitlin, B. R., Thiessen, R., and Murer, H. K., *J. Pharmacol.*, **118**, 348 (1956).

[6] Leach, E. H., and Lloyd, J. P. F., *Proc. Nutrition Soc.*, **15**, XV (1956).

NEW LABORATORIES AT UPPINGHAM SCHOOL

THE new Science Laboratories at Uppingham School, which were inaugurated by H.R.H. Prince Philip, Duke of Edinburgh, on November 8, owe their existence to the imaginative and far-sighted generosity of British industry.

The old Science School, built in 1897 and partially modernized and extended in 1927, was proving inadequate even before 1939 because of the increasing number of boys who were specializing in science. The great impetus given to the teaching of science during and since the War had made the provision of additional laboratory accommodation imperative. The buildings could not have been modernized satisfactorily, and space for their extension on the existing site was inadequate. Plans were therefore drawn up for the building of a new Science School, but these could not have been carried out without the generous financial help of the Industrial Fund for the Advancement of Scientific Education in Schools and many firms, which contributed a large proportion of the £100,000 needed for the building.

The new Science School was designed by Messrs. Easton and Robertson, of London, and built by Messrs. E. Bowman, of Stamford. It has the shape of the letter H and consists of two floors.

The Chemistry Department includes two large chemistry laboratories (1,100 sq. ft), one specialist laboratory (540 sq. ft.) and two lecture theatres on the ground floor. Each of the large laboratories is fitted with three island benches (16 ft. × 4 ft.), which can comfortably accommodate twenty-four boys (4 ft. bench space a boy), and there is additional space on the benches which extend down the two long sides of each laboratory. A special feature of these laboratories, apart from their spaciousness, is the generous provision of cupboards and drawers, so that all the apparatus which is in general use can be kept in the laboratories. There are large fume chambers at one end and a raised demonstration bench at the other.

The specialist laboratory has been designed mainly for third-year sixth-form work. It can accommodate twelve boys and contains a thermostat and the more expensive apparatus that is needed for advanced work. It is separated from the senior (sixth-form) laboratory by a balance room, which contains concrete shelves on concrete pillars. This arrangement has proved most satisfactory, because there is no noticeable vibration from the traffic on the main road which passes within 70 yd. of the building.

The two lecture theatres contain tiered benches, a well-equipped demonstration bench and a fume chamber, and blinds so that they can be blacked out for the showing of films, etc. Like the laboratories, they are within easy reach of the chemistry store and preparation room. Although the maximum size of a form is usually twenty-four, these theatres can accommodate fifty boys, which is very useful for the showing of films to two forms simultaneously.

The Biology Department consists of two laboratories, a preparation room, a greenhouse, a small botanical garden, and upstairs a large lecture theatre and small museum.

The laboratories are fitted with working benches each specially designed in rows to accommodate four boys. Each working space is 4½ ft. long, with a bench top 30 in. deep. There is a sink between each pair of places, and beneath are drawers. All positions have gas and mains electricity, and face the main windows to facilitate microscope work in daylight.

Special features of the elementary laboratory include built-in racks for aquarium tanks, a galvanized tank alongside the main wash-up sink for preserving specimens used for dissection, and spacious glass-fronted cupboards.

The advanced laboratory, used primarily by boys taking botany and zoology as separate subjects at Advanced Level of the General Certificate of Education examination, is equipped for both lectures and practical work. It has black-out and facilities for projection. It also contains a light-proof cupboard similar in construction to a standard fume chamber, in which plant physiology experiments can be carried out in the dark.

The preparation room is designed to enable the staff and assistants to prepare specimens, microscope slides, etc., without interference, and for senior boys to set up long-term experiments. There is adequate storage space for reagents and equipment.

The greenhouse communicates directly with the elementary laboratory and is large enough to provide

the Department with adequate plant material, and also give space for growth experiments, etc. The garden will lie between the greenhouse and the chemistry wing, facing west, and will include a water garden.

The lecture theatre has accommodation for an audience of 120 on tiered benches; but for class teaching only the front rows are used, and these have tops broad enough to take the drawing boards and books required for normal class-work. Black-out is fitted, and the room is equipped for cinema-, still- and micro-projection.

The museum is intended to house teaching collections of animals, the school herbarium collection and the results of work done on the annual Easter expeditions.

The Physics Department (together with a staff room and library) occupies the rest of the first floor, and comprises two large laboratories, one for elementary work up to Ordinary Level of the General Certificate of Education examination and the other for more advanced work. As annexes to the latter, there are an advanced laboratory proper and a dark-room for optical experiments which will between them accommodate about twenty boys, and in which the apparatus for a lengthy piece of work can be left undisturbed. There are also two tiered lecture rooms, each with 16-in. dial ammeter, voltmeter and centre-zero galvanometer mounted above the blackboard, and one containing a 'dry' cupboard for electrostatics apparatus. The electrical installation provides d.c. variable between 4 volts and 108 volts, from lead–acid cells charged by a rectifier unit; and also low-voltage (12-volt or 24-volt) 50-cycle a.c. Sufficient working points are available for class experiments on alternating current. The physics workshop, with wood-working bench, lathe, power-drill and glass-blowing table, is equipped for the making of most ordinary pieces of apparatus, as well as for routine repair and maintenance work.

SPATIAL ASYMMETRIES IN π—μ DECAY

SOME interesting observations on the decay of pions at rest in a nuclear emulsion, made by a group of physicists at the Institute of Atomic Physics at Bucharest, were recently presented to the French Academy of Sciences*. The emulsion was exposed to pions produced by the large synchro-cyclotron at the Institute of Nuclear Research near Moscow. The π–μ decay events were classified into two groups, depending on whether the muon momentum was directed forwards or backwards with respect to the pion momentum immediately before stopping. In a total of 3,595 events, 2,199 backward and 1,396 forward decays were seen. If the angular distribution is of the type $(1 + b \cos\theta)$, where θ is the angle between the two momenta, then b is found to be $-0{\cdot}447 \pm 0{\cdot}032$. Such a large asymmetry parameter b, differing from zero by more than 14 standard deviations, clearly cannot be ascribed to a statistical fluctuation.

An asymmetry in π–μ decay could mean that the pion has a finite spin (most plausibly 2 units of $h/2\pi$) with which to 'remember' its direction of motion before stopping. Such a conclusion would be quite contrary to all previous ideas about pion phenomena, which are easily and consistently interpreted on the basis of zero spin for the pion. It should also be noted that a longitudinal polarization of the pion beam used in the experiment would almost certainly mean that parity was not conserved in the production process, although it is possible to imagine an unusual magnetic-field arrangement which would invalidate this conclusion. Non-conservation of parity in a 'strong' process such as pion-production would be hard to reconcile with the observed conservation of parity in nuclear forces.

Alternatively, and much more drastically, the effect could mean that current ideas about space, which lead to connexions between angular momenta and spatial probability distributions, are false. This would be an extremely fundamental conclusion, but recent experience with the parity hypothesis has taught physicists to be cautious about rejecting all idea of changes of this kind.

At the International Conference recently held in Padua and Venice, several groups working with nuclear emulsions reported finding various kinds of anisotropy in π–μ decays. In each case, however, the experiment had been extended to the electrons afterwards emitted in μ–e decay. The angular correlation in the μ–e decay is well known and comparatively small in nuclear emulsion (asymmetry parameter numerically smaller than $-0{\cdot}20$). It follows that the π–e correlation, through two decay processes, should be much smaller than the simple π–μ correlations. This was not found to be true, indicating that the effects observed were not physical, but due rather to hitherto unsuspected distortions or scanning biases in nuclear emulsion work.

At the same conference, Prof. L. M. Lederman, of Columbia University, New York, reported some work using counters and electronic recording of the events (Garwin, Gidal, Lederman and Weinrich, unpublished). In the horizontal plane, they find an asymmetry parameter in the π–μ process of $0{\cdot}025 \pm 0{\cdot}025$, essentially a zero result. The up-down asymmetry parameter was $-0{\cdot}016 \pm 0{\cdot}012$, again showing insignificant deviation from isotropy.

J. M. CASSELS

* Hulubei, H., Ausländer, J., Balea, E., Friedländer, E., Titeica S., and Visky, T., *C.R. Acad. Sci., Paris*, **245**, 68 (1957).

A GEOCHEMICAL HYPOTHESIS OF THE EARTH'S STRUCTURE*

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GOLDSCHMIDT'S view that the interior of the Earth resembles the hearth of a smelting furnace and that the Earth is zonal in its structure, with each zone characterized by certain dominant elements, has long prevailed in geochemistry. In recent years, however, these views have been critically examined, and many scientists, such as V. N. Lodochnikov, consider a chemically homogeneous, non-zonal globe much more probable.

In two recent papers[1] I have examined this problem in detail and here I would like to give a brief summary of the conclusions I have reached.

* Summary of a paper read at the Symposium on Geochemistry held in Paris in July 1957.

In the first instance, in my opinion, we cannot accept Goldschmidt's views, as they are based on a conception of ordinary behaviour of matter. As we shall see later, the properties of matter and the properties of atoms remain constant only in the crust of the Earth, whereas under pressure of hundreds of thousands of atmospheres, the properties of matter change so much that the very nature and direction of physical and chemical processes become altogether different.

On the other hand, the Earth cannot be regarded as homogeneous. The Earth's core, for example, is probably rich in iron, and modern seismology supports very strongly the existence of geo-zones having different physical properties. But at the same time, it is clear that classical chemistry, based on the Mendeléeff periodic law and the Pauli exclusion principle, cannot be applied to matter composing the Earth as a whole. The study of the Earth requires a new and more fundamental approach, based on new findings relating to the behaviour of matter under very high pressure.

It is now known that with increasing pressure the outer electrons of the atoms are forced into the lower quantum-levels, a process eventually leading to the occupation by the electrons of all the unfilled positions in quantum-levels. For example, while under ordinary conditions calcium has two outer electrons at the level 4*s*, and the level 3*d* is unfilled, under pressure we may expect an 'isomerization' and the transformation of ordinary calcium into '*iso*-calcium', in which the two 4*s* electrons are displaced into the 3*d* level. Since the chemical properties depend primarily on the electron quantum characteristics, this new atom would have completely new properties.

According to R. Sternheimer's[2] calculations, the pressure under which the outer electrons are pushed into the lower quantum-level, for cæsium, for example, is of the order of 45,000 atm., which corresponds to a depth of about 100 km. of the Earth's crust. Allowing variation among different elements one may assume this depth to vary from 60 to 120 km., being the lower boundary of a geo-zone called by me the 'perisphere' and which corresponds to the well-known Mohorovičić discontinuity. The 'perisphere' is followed by the 'intersphere' to a depth of 2,900 km. This zone is made of atoms with 'degenerate chemical properties'. Finally, at the centre of the Earth is the 'centrisphere', which is the region of 'squashed' atoms.

In my two papers[1] I have discussed a concept which I have called 'periodicity function'—a mathematical expression, based on empirical data, which shows at what pressure all of the elements are modified to such a degree as to lose their property of periodicity; in other words, at what pressure all atoms will become identical in respect of their chemical properties. According to my calculation such a pressure will be of the order of 1,400,000 atm., corresponding to a depth of 2,900 km. Certain works by Ramsey, Kuhn, Wigner, Huntington and others have a bearing on the development of this idea, as well as my own researches on the thermodynamics of compressed crystals, which represent further expansion of the idea of Lewis that the entropy of a highly compressed crystal tends to zero.

Thus I assume that at the high pressure prevailing in the 'centrisphere' all atoms will be in a 'metallized' state, in which matter will be made of atomic nuclei immersed in a homogeneous electronic 'plasma'. Having no specific electrons attached to them, atoms will cease to be separate elements with definite atomic numbers, definite chemical properties and reactions in this region of 'zero chemistry'. On the other hand, in this state matter will be characterized by such a high electrical and thermal conductivity that the temperature of the whole of the 'centrisphere' will remain constant.

The geochemical hypothesis of the structure of the Earth briefly expounded here requires verification and amplification. It finds its support in certain thermodynamical considerations and seems to agree with the seismological data. In any event, such a hypothesis may stimulate further research and point to new concepts of Nature.

[1] Kapustinsky, A. F., "Problems of Geochemistry and Mineralogy", *Acad. Sci. U.S.S.R.*, 37 (1956); "Geochemistry", *Acad. Sci. U.S.S.R.*, **1**, 53 (1956).

[2] Sternheimer, R., *Phys. Rev.*, **78**, 235 (1950).

DEPENDENCE OF HEAT CAPACITY OF CERTAIN CRYSTALS ON THEIR THERMAL HISTORY

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DURING a study of the heat capacities of ammonium and alkali stannihalides, designed to throw light on the motion of the ammonium ion in these salts, we have encountered a phenomenon for which, so far as we are aware, there is no precedent. This is that the heat capacity over a considerable range of temperature becomes less after the sample has been cooled to low temperatures, and only reaches steady, reproducible values after repeated cooling. The effect was most fully investigated for potassium stannichloride, some results for which are shown in Fig. 1. In this figure, in which the molar heat capacity C_p is plotted against absolute temperature in the range 270–300° K., the open circles represent the first values obtained after the calorimeter had been filled and assembled. When these measurements were made, the sample had not been cooled to below ~245° K. The full circles show the values obtained three weeks later, during which time the calorimeter had been repeatedly cooled (on two occasions to 20° K.) and heat capacity measurements made from 20° K. upwards. A week later, during which period the calorimeter had been cooled several times (though not below 195° K.), a redetermination of C_p gave the values plotted as crosses. After another week, during which the calorimeter was cooled to 90° K. four times, and allowed to warm slowly to room temperature after each cooling, the C_p values (shown as triangles) did not depart significantly from the curve through the crosses. Further experiments

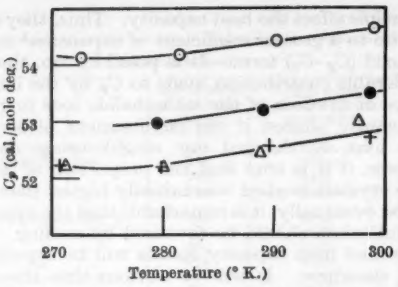

Fig. 1. Molar heat capacity, C_p, of potassium stannichloride in the range 270–300° K., showing the decrease in C_p with repeated cooling of the salt

confirmed that these final values were reproducible. The overall drop in C_p amounted to about 4 per cent.

It must be stressed that the results shown in Fig. 1 were obtained with the same sample throughout. The calorimeter used was that described by Davies and Staveley[1]. Similar effects had never been obtained with it before, and there was no reason whatever to suspect misbehaviour on the part of the platinum resistance thermometer or the heating circuits. Since progressive desorption of, say, water vapour from the surface of the calorimeter would produce a drop in its heat capacity, particular attention was paid to the evacuation of the space around the calorimeter before any measurements were started. A possible source of a changing heat capacity could be chemical reaction between the salt and the copper calorimeter, and after the experiments on potassium stannichloride the sample was removed from the calorimeter and analysed, and the inside of the calorimeter thoroughly washed out to see if any such reaction had taken place. It was found that, in fact, there had been a slight attack on the copper, but analysis showed that, at the most, not more than 0·2 per cent of the salt could have been affected. Furthermore, such a reaction would not lead to a marked decrease in heat capacity. Thus, a mixture of potassium chloride, stannous chloride and cupric chloride—the most probable reaction products—would have a total heat capacity at room temperature within a few per cent of that of equivalent amounts of potassium stannichloride and copper; as a rough estimate, reaction of 0·2 per cent of the potassium stannichloride in this way would not have changed the heat capacity by more than $\sim 0{\cdot}01$ per cent. Clearly the observed decrease of about 4 per cent was not due to reaction or decomposition of the salt. Evidence to support this is provided by (1) below.

A full understanding of the phenomenon must await a detailed examination of the properties of the salt before and after cooling, but the following observations are relevant, and would have to be considered in any attempted explanation:

(1) The change in C_p is due to cooling, and not simply to ageing. In another series of experiments on potassium stannichloride, C_p was measured between about 267–300° K. without cooling the salt below about 260° K., using a sample which had been standing at room temperature for 15 weeks. After allowing the calorimeter to stand for a further three weeks at room temperature, C_p was measured again over the same range and, within the precision of the measurements (± 0·2 per cent), was found to be unchanged. The sample was then cooled to 90° K. and allowed to warm to room temperature. This was repeated five times in a week, and C_p was then redetermined. The values obtained were lower by about 2 per cent at 300° K.

(2) The effect was also observed with ammonium and rubidium stannichlorides, and potassium stannibromide. Some of the experiments on these substances were carried out before we had become fully aware of the phenomenon, and the initial measurements of C_p at higher temperatures were sometimes made after the sample had been cooled at least once to liquid-oxygen temperature. Consequently the observed drop in C_p with further cooling was not as marked as with potassium stannichloride. The decrease in C_p at room temperature between the first values and the final steady values was ~ 1 per cent for ammonium and rubidium stannichlorides and $\sim 2{\cdot}5$ per cent for potassium stannibromide.

(3) With each salt, the change in C_p was only apparent in roughly the upper half of the temperature-range covered (20–300° K.). Thus for potassium stannichloride all C_p values obtained below about 115° K. follow the same curve, regardless of the stage in the history of the sample at which they were measured. From about 115° K. upwards, a curve through the first values of C_p diverged more and more from the curve through the points accepted as the 'final' values. (See Fig. 2.) The corresponding temperature for ammonium stannichloride was about 200° K.

(4) Extensive X-ray diffraction studies have been made of these and similar salts of the type R_2MX_6, where R is a univalent cation and X is a halogen. With the possible exception of potassium stannibromide, they are all said to have anti-fluorite structures, with the M–X bonds directed along, or parallel to, the sides of the cubic unit cell. Potassium stannibromide was considered to have the same structure by Ketelaar, Rietdijk and Staveren[2], but Markstein and Nowotny[3] concluded that it is tetragonal, with a and c parameters differing by about 1 per cent. The samples used in the calorimeter were prepared by slow evaporation at room temperature from solutions containing the stannic halide, the alkali or ammonium halide, and free halogen acid to avoid hydrolysis. All four salts gave satisfactory analyses. The crystals were usually large and well formed, some being several millimetres across. In order to be introduced into the calorimeter they had to be lightly crushed. They were then sieved, and the

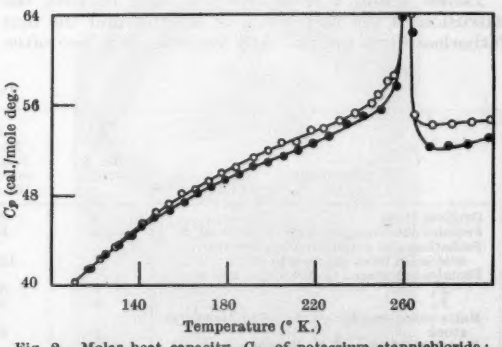

Fig. 2. Molar heat capacity, C_p, of potassium stannichloride: open circles, first measurements; full circles, measurements on the same sample after repeated cooling

fines rejected, so that the measurements were made on crystals of size roughly 0·5–1 mm.

(5) Potassium stannichloride was found to have a λ-point with C_p reaching its maximum at 262·1° K. (This means that the crystal structure of this salt at lower temperatures, at least, is not so simple as the previous crystallographic work has suggested.) The decrease in C_p with repeated cooling was apparent both above *and* below the λ-point. This is shown in Fig. 2.

It may be that the phenomenon we have described arises because the crystals are formed with a higher proportion of defects than they eventually possess when equilibrium has been achieved. Although nothing appears to be known about defect concentrations in salts of the type R_2MX_6, it is possible that such salts, even at room temperature, contain a relatively high proportion of Frenkel defects. The inter-ionic forces must be weaker than in salts composed solely of monatomic ions, and there is a considerable difference in size between anion and cation. Moreover, the nature of the lattice is such that cations might be accommodated in the octahedral interstices between the anions. Such defects must in principle affect the heat capacity. Thus, they could give rise to a greater coefficient of expansion[4] and an enhanced $(C_p - C_v)$ term. It is possible, too, that the considerable contribution made to C_p by the internal degrees of freedom of the stannihalide ions might be significantly altered if the environment of some of these ions is changed by neighbouring defects. However, if it is true that the proportion of defects in the crystals studied was initially higher than that reached eventually, it is remarkable that the approach to equilibrium should be favoured by cooling.

The final heat capacity results will be reported in detail elsewhere. It will be obvious that the effect we have described, whatever its cause, could lead to considerable discrepancies between the heat capacity results of different observers for substances subject to it.

We are grateful to Prof. F. C. Frank for a helpful correspondence, and to Imperial Chemical Industries, Ltd., for financial assistance.

[1] Davies and Staveley, *Trans. Farad. Soc.*, **53**, 19 (1957).
[2] Ketelaar, Rietdijk and Staveren, *Rec. Trav. Chim.*, **56**, 907 (1937).
[3] Markstein and Nowotny, *Z. Krist.*, A, **100**, 265 (1939).
[4] Lawson, *Phys. Rev.*, **78**, 185 (1950).

HERMAPHRODITISM WITH SELF-FERTILIZATION, AND THE MONTHLY EXTRUSION OF UNFERTILIZED EGGS, IN THE VIVIPAROUS FISH *LEBISTES RETICULATUS*

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THIS communication is a preliminary report on two independent phenomena: first, functional hermaphroditism, resulting in self-fertilization, has been observed in a fish and eighteen of her descendants; secondly, in all but two families in which more than one female became adult, one or more fish has extruded groups of unfertilized oocytes into the surrounding water. Such extrusions have occurred in fish unrelated to the hermaphrodites. Both kinds of abnormal parturition were discovered by keeping virgin females alone in small glass vessels (usually in 600 c.c. of water). The baby fish were always isolated before puberty and usually within 24 hr. of birth.

Tables 1 and 2 show that the ages of both the extrusion of the first group of oocytes and the first fatherless birth are not only variable, but also often higher than the median ages of death. Also some fish (not chosen at random) are removed from the populations either to be mated for genetical experiments or killed for histological examination. Therefore a meaningful estimate of the frequencies of fish which perform either of these two abnormal parturitions, and comparison of these frequencies between families, involves statistical procedures the assumptions of which require discussion. A full analysis was delayed until the population here discussed and kept in the Department of Biometry, University College, Gower Street, London, was discarded in July 1957.

Lebistes reticulatus is a typical poecilid fish in which internal fertilization is effected by copulation. The anal fin of males develops into an intromittent organ

Table 1

1 Parentage	2 No. of families	3 No. of females surviving 100 days	4 Median ages at death	5 No. of self-fertile females	6 No. of females extruding oocytes	7 Corrected median age at first oocyte extrusion
Original stock	5	39	500–599	3	6	∞
Females outcrossed to males from stock *B*	3	61	500–599	9	21	800–899
Fatherless and grandfatherless females descended from outcross to stock *B*	17	121	400–499	6	46	400–499
Females outcrossed to *Maculatus* males						
F_1	6	81	500–599	0	41	400–499
F_2	1	19	200–299	0	1	252
Males outcrossed to females from *Maculatus* stock	5	64	900–1,000	0	41	300–399
Maculatus stock and F_1 *B* male × '*Maculatus*' female	7	58	400–499	0	15	400–499

Table 2

Self-fertile mother			Fatherless family						
	Age at birth of first litter (days)	Age when removed from population	Ref.	No. of litters	No. of births dead	No. of births alive	No. of adults Female	No. of adults Male	No. of adults Intersex
*D*9 proposita	216	519*m* ±	*D*99	1	0	1	1	0	0
*DD*20 fatherless	197	367*m* +	*J*	1	0	3	3	0	0
*DD*9 ?	263	549*d*	*K*	1	0	5	5	0	0
*DD*22 ?	266	367*m* +	*L*	1	0	1	1	0	0
*P*3 F_1 with stock *B*	184	235*d*	*α*	2	0	17	12	0	0
*P*8 ,, ,,	184	494*k*	*β*	2	0	8	6	0	0
*P*25 ,, ,,	262	407*d*	*ε*	4	9	105	31	1	1
*P*26 ,, ,,	264	632*m*	*ζ*	2	0	9	8	0	0
*P*39 ,, ,,	516	531*d*	*λ*	1	6	24	2	0	0
*P*29 ,, ,,	650	663*d*	*π*	1	2	10	6	0	0
*P*41 ,, ,,	863	888*d*	*σ*	1	0	17	10	0	0
*S*7 ,, ,,	769	770*m* – 848*d*	*χ*	3	7	20	3	1	0
*Z*2 ,, ,,	587	588*m* +	*ψ*	1	2	20	15	2	0
*ε*26 fatherless intersex	215	443*d*	*θ*	9	47	25	13	0	0
*ε*51 ,,	280	479*d*	*μ*	4	3	8	7	0	0
*ε*5 ,,	379	380*m* +	*ξ*	1	0	4	4	0	0
*β*7 ,,	277	278*k*	*ι*	1	0	1	1	0	0
*μ*7 ,,	317	318*k*	*ε*	1	0	1	1	0	0
*χ*8 ,,	146	413*d*	*ghα*	2	0	8	2	0	0

during the first eight weeks of life. Sperm from a single copulation can sire up to eight litters[1]. These are born at approximately monthly intervals[2,3] (but see also Fig. 4), and the young are 5–6 mm. long at birth.

Lebistes males are bright coloured and variable; wild-type females are monomorphic and have a typical teleostean shape. Usually the males are heterogametic (or *XY*) and the females homogametic (or *XX*). *XX* and *YY* males and *XY* females can be functionally normal[4].

Nineteen individuals all related to one another have produced fatherless offspring. Eighteen of these were superficially normal females. The anal fin of the nineteenth developed into an intromittent organ coincidentally with the birth of its first litter. With this it made courtship movements but did not sire any young on unrelated females. It was found to contain testicular tissue by M. J. Hollingsworth, now of the University College of Ghana, Achimota, who failed to discover any testicular tissue in two other self-fertile mothers, *P*8 and β7. However, Prof. J. Z. Young, of University College, London, discovered testicular tissue in the self-fertile females *S*7 and *μ*7 (Figs. 1 and 2). I wish to thank both these colleagues, and their assistants, for this histological co-operation.

The self-fertility is, therefore, assumed to be due to hermaphroditism and not to parthenogenesis, as was stated previously[5].

The self-fertile proposita *D*9 occurred in an inbred aquarium stock given me by Maurice Wilson, now of Queen Mary College, London. This was segregating for alleles of the loci *Flavus*[4], *blond*[6] and *gold*[6], all affecting pigmentation and scorable on females. These were used for diagnosing paternity when self-fertile or related females were mated. The sex ratio among certainly sired offspring was normal. There

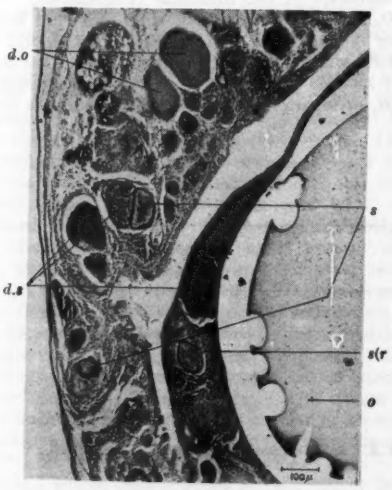

Fig. 1. Section of ovotestis of *μ*7

Key: *d.o*, developing oocytes; *d.s*, developing seminiferous tubules; *o*, yolk of mature oocyte; *s*, seminiferous tubules containing mature sperm; *s(r)*, ruptured seminiferous tubule liberating sperm (this rupture is not certainly an artefact of preparation and it may be by such means that the sperm and the oocytes come into contact)

Fig. 2. Another section of the ovotestis of *μ*7. Key as for Fig. 1

is no evidence for self-fertilization first occurring in an animal after it had been in the company of a male.

Table 1 shows the incidence of the self-fertility and oocyte extrusion in the animals born in the collection. The first column gives a classification of the animals in terms of parentage.

Sired and fatherless females are classed together as the original 'stock' (excluding twenty-one females including the proposita, because they were kept in aquaria where young, but not oocytes, could have been detected). Females (self-fertile, and fatherless and sired daughters and grand-daughters of self-fertile females) were outcrossed to males from two stocks, for which I wish to thank Dr. Caryl Haskins, of the Carnegie Institution of Washington. Stock *B* was descended from a recent capture in Trinidad; the *Maculatus* stock was a subculture of that produced by Winge, and thus X_0Y_{Ma} in his nomenclature[4]. Sons, both fatherless and sired, of self-fertile females derived from outcrosses to *B* were crossed to females from the *Maculatus* stock, that is, X_0X_0.

In Table 1, column 2 shows the number of families in each of the six groups, and column 3 the number of females who survived 100 days. Column 4 is a rough estimate of their median age of death. The families within a given group are not homogeneous among themselves.

Column 5 shows the number of females which have been self-fertile. The absence of self-fertile females among the progeny of *Maculatus* males, compared with the progeny of stock *B* males, is significant after allowance has been made for the detailed longevity of the females tested. Column 6 gives the number of females which extruded oocytes (excluding six which extruded them synchronously with full-term young, two which had previously given birth to fatherless litters and four which had previously given birth to sired litters).

Table 2 shows some details about the self-fertile mothers and their fatherless litters, and the extract from the pedigree given in Fig. 3 shows the relationship of the parents of the five sired families (*D*, *DD*, *P*, *S* and *Z*) in which self-fertile individuals have segregated.

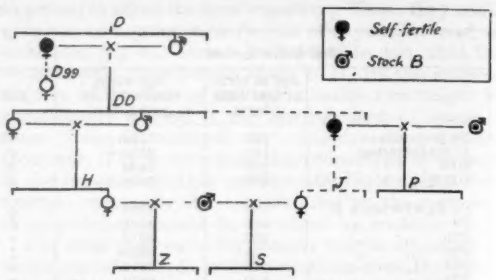

Fig. 3. Part of pedigree showing relationship of parents of the five fathered families in which hermaphrodites segregated

The range of the mothers' ages at the birth of their first fatherless litter means that some apparent females must die before they become old enough to manifest their hermaphroditism by a parturition, and perhaps before any testicular tissue has developed. Such variation in expression would prevent any Mendelian ratios being observed even if the hermaphroditism were due to a change of allele at a single locus. It also makes it difficult to compare such a change with the non-functional hermaphroditism which seems characteristic of the development of lower vertebrates[7,8].

The third column shows the age at which the mother was removed from the population either by death (*d*), killing (*k*) or introducing a male (*m*+ if producing sired offspring, or *m*− if subsequent litters were recognized as products of self-fertilization on the evidence provided by their alleles for the three pigment genes).

Within the fatherless families there is positive correlation between the number of litters, the size of these litters, and the number of miscarriages and deaths before puberty; that is, as would be expected, the greater the development of the testis tissue the greater the number of conceptions but also the greater the disturbance of the follicular pregnancies.

*DD*20, the one certain fatherless offspring born to *D*9 after it had been mated, was in its second sired litter born when *D*9 was 594 days old. The second litter of X8 was produced when the mother was 293 days old, an extrusion of unfertilized oocytes having

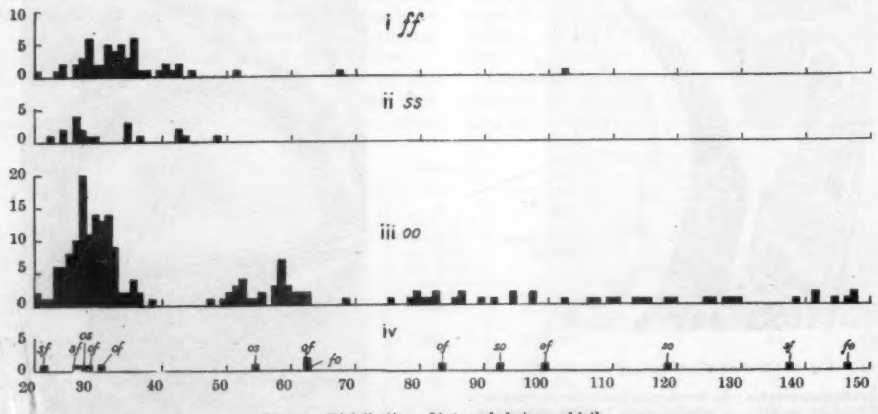

Fig. 4 Distribution of intervals between births

Abscissæ, length of interval in days. Ordinates, number of intervals. *f*, fathered litter; *s*, fatherless litter; *o*, oocyte extrusion (for omissions see text)

intervened at 265 days. All other intervals between fatherless litters are shown in histogram ii of Fig. 4. This distribution is statistically indistinguishable from that observed for the production of sired litters (histogram i). This confirms the histological findings that the testis tissue is transitory and usually does not re-develop.

I have discussed elsewhere[9] the significance of the increased expression of self-fertility in the F_1 generation between two inbred stocks which is unexpected on certain interpretations of heterosis. Table 2 corrects several previously published errors in addition[9].

The last three columns of Table 2 give the superficial sex of the adult products of self-fertilization. Among the animals scored as females, many more than the five who were self-fertile must be presumed to be actually or potentially hermaphrodites. This sex ratio suggests that the hermaphrodites are *XX*, which is supported by the phenotypes and the sexual history of the four males. All were under-coloured, and no *Y* chromosome empty of alleles for male epigamic patterns has yet been reported. Three were sterile, though one of these had histologically normal testes. The fourth provided evidence for its *XX* constitution by siring only females, sixteen of which were by a *Maculatus* stock female.

Among fatherless fish, the three colour alleles segregated in the 3 : 1 ratio characteristic of selfing in hermaphroditic plants.

The hereditary factor responsible for making *XX* zygotes develop into hermaphrodites is not *X*-linked, and is not an autosomal recessive allele either with or without a delayed zygotic effect. Because the crosses were made with the *Maculatus* stock which suppresses their penetrance, we do not know whether the determiners are inherited differently through males or females; that is, I have not discovered whether hermaphroditism is dependent on an autosomal allele with dominant but variable penetrance, or on a cytoplasmic factor comparable with those influencing hermaphroditism in some species of plants[10].

Histogram iii of Fig. 4 shows the distribution of 200 of the 222 intervals observed between two extrusions of oocytes. The 22 omitted intervals ranged in length from 165 to 447 days. The distribution of these intervals is significantly different from that of the intervals between births. 126 (that is, more than half) ranged between 21 and 39 days, and this group did not deviate significantly from the normal distribution. Its mean was 29·4, and its standard deviation 3·4. This is significantly lower than the mean observed for sired litters, which is 33·0, with standard deviation 5·16 even when the three extremes are neglected. The next group of thirty-five intervals between oocyte extrusions ranged from 48 to 69 days, again normally distributed among themselves with a mean of 57·1 and standard deviation of 4·6. These groups are called 'single' and 'double' intervals, respectively. The range of the single intervals is too great for groups to be apparent if higher multiples of these do occur among the longer intervals between extrusions.

Table 3 shows that (except for the oldest two fish) the greater the age of a fish at its first extrusion of oocytes the greater the mean number of its subsequent extrusions. Omitting from consideration inadequately tested animals, 73 females first extruded before 300 days but not one extruded more than five times; though of the 64 which began later, eight produced six to ten groups of eggs. This is unexpected, because the earlier in its life a fish extrudes oocytes the longer is the expected (and observed) period before its death in which subsequent extrusion could occur. This correlation is partly explained by the observation that the greater the age of a fish at its first extrusion of oocytes, the higher is the proportion of single intervals between consecutive extrusions to all such intervals.

Table 3

Age at first extrusion	Mean No. of extrusions	Ratio of single intervals to all intervals
100–199	2·18 ± 0·19	0·450 ± 0·076
200–299	2·41 ± 0·22	0·433 ± 0·064
300–399	2·20 ± 0·34	0·567 ± 0·090
400–499	2·30 ± 0·88	0·714 ± 0·121
500–599	3·5 ± 1·5	0·615 ± 0·135
600–699	3·6 ± 0·44	0·609 ± 0·104
700–799	4·5 ± 1·18	0·857 ± 0·076
800–899	3·25 ± 0·62	0·800 ± 0·089
900–999	1·5 ± 0·5	0·0 (1 interval)

Extrusion reveals a failure of the follicles to re-absorb unfertilized oocytes. In the females which begin this extrusion late in life and then extrude regularly, this failure may be described as a senility and is then mainly dependent on a monthly rhythm of oocyte maturation[3]. In the animals that extrude earlier, and afterwards extrude intermittently or not at all, other causes of ovarian inadequacy must be suspected, some of which seem transitory. In some families, perhaps in all, the females which extrude oocytes live longer (for example, a mean increase of more than 300 days) than their sisters who do not. This suggests that extrusion itself compensates for failure of other processes, and prevents the animals becoming 'egg bound'.

Histogram iv of Fig. 4 shows the distribution of the intervals between two different kinds of parturition. Two *fo* of 201 and 740 days and 3 *sf* of 210, 340 and 385 days are omitted. This histogram reveals that oocyte extrusion is not evidence that the ovary has become incapable of pregnancy. Also, when it is borne in mind that the interval before a sired birth depends on when the male was introduced as well as on the mother's receptivity, and that the senile oocyte extrusion may not occur until many months after sperm has been exhausted, it is seen that oocyte extrusion coincides reasonably well with the rhythm of other births. It has also occurred six times with them. Therefore, the breakdown of the follicular walls may be a failure of an incipient pregnancy because the oocyte was not fertilized; that is, the extrusions seem more comparable to the menstruation than to the ovulation of mammals.

The gross synchronizing regulations which take place in the follicles just before term[2] provide an explanation of the significantly longer intervals observed between fertile parturitions and perhaps for the positively skew distribution of these intervals.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Significant Error in the Determination at Low Pressures of the Virial Coefficients of Vapours

The differential method[1] which we have developed and which has been applied successfully to the accurate measurement at low pressures of the deviations from ideality of a number of gases has, with vapours, been found to give unreliable results. Usually, with these the PV/P isothermals show a curvature concave towards the pressure axis. This effect was noticed by Casado[2] with benzene vapour, and the literature contains references to curved low-pressure isothermals with several easily liquefiable gases. Hamann and Pearse[3] noticed this behaviour with methyl chloride and methyl bromide. Since, on theoretical grounds, it is very unlikely that a third virial coefficient could produce an effect of the magnitude observed even in benzene, it is clear that an experimental error of some significance is involved. This error is due to adsorption, which hitherto has been neglected by other workers in this field.

Now that a careful investigation of adsorption on 'Pyrex' glass of a series of vapours at various temperatures has been made by one of us[4], it is possible to define the conditions in which this error is at a minimum and to make reliable corrections in volumetric work. It was found that only when the glass surfaces in the volumeters were scrupulously clean and the mercury in contact with them entirely free from even traces of grease that minimum and constant values for adsorption could be obtained.

It was hence imperative to redesign the differential compressibility apparatus so as to avoid entirely the passage of mercury through greased stopcocks. This has now been done by using magnetically controlled mercury valves which permit the necessary fine adjustment[5], and results obtained for benzene vapour at 22° and 35° C. between the pressure limits of 60 and 20 mm. The PV/P graphs, after correcting for adsorption, are very closely linear and the deviations of the experimental points from a mean square line do not exceed 2 parts in 10^5. The virial coefficient at 22°, deduced from the slope of the line, is $-B = 1{,}525$ c.c./mol. In the particular apparatus used the increase in surface on expansion is nearly balanced by the decreasing adsorption, so that the total adsorption correction is small and even at the lower temperature does not exceed 30 c.c./mol., or about 2 per cent; at 35° it is still smaller.

As a check to these results, we have compared the balancing pressures of benzene vapour and nitrogen by means of the microbalance. Originally, Casado, Massie and Whytlaw-Gray[6] compared benzene vapour with oxygen and obtained a value for the molecular weight from the limiting value of the pressure ratio very close to the accepted figure, but for the virial a high degree of accuracy was not claimed and we had reason to suspect that the balance used might not have been sufficiently compensated for adsorption. Imperfect compensation would affect significantly the value of the virial coefficient but would have little influence on the molecular weight. Using a more certain method of compensation for adsorption, we now find, as the mean of two sets of experiments, $-B = 1{,}537$ cal./mol. in good agreement with that found with the modified compressibility apparatus. At 35° C. also a satisfactory agreement between the two methods has been attained. Although with the microbalance the accuracy of the results is not as great as with the compressibility method, the agreement supports the view that systematic errors have been avoided.

From the form of the adsorption curves on 'Pyrex' there is a great increase as the saturation point is approached, and on silica at 22° C., although the adsorption is not so great as on 'Pyrex' glass, it increases nearly threefold between 68 and 90 per cent, so that measurements made near the latter point are likely to be adversely affected unless adequately corrected.

It is likely that some of the published data on compressibilities at low temperatures may be in error unless adsorption is taken into account.

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Travelling Disturbances in the Ionosphere: Changes in Diurnal Variation

In an earlier communication[1] it was reported that the direction of horizontal movement of travelling ionospheric disturbances observed at Sydney, Australia, had a consistent diurnal variation during winter months in the years 1950–52; but no significant diurnal variation was then apparent in the summer. These conditions continued until 1955; but in the summer of 1955–56 a definite change appeared which was even more marked in 1956–57, the main feature being a marked change of direction from the south-east to the south-west quadrant about midday. The contrast is clearly evident in Fig. 1, which shows the mean diurnal variation in January for the years 1951–54 as compared with the variation for January 1957. The consistency of the results of 1951–54 is shown by the dotted lines, which indicate maximum deviation from the mean. It will be noted that the change from south-east to south-west quadrant in 1957 is quite sudden. This sequence is also found on a number of individual days, though not on all days. There was no significant change in mean speed over this time interval.

Examination of past records starting from the summer of 1949–50 shows that there was a tendency for a similar sequence to occur on occasional days in that year but not sufficiently often to affect the mean curve for the month. This tendency, however, decreased in succeeding years to a minimum in 1953–55. It then increased noticeably in 1955–56 and markedly in 1956–57.

It seems likely that these changes are associated with the sunspot cycle, which showed minimum

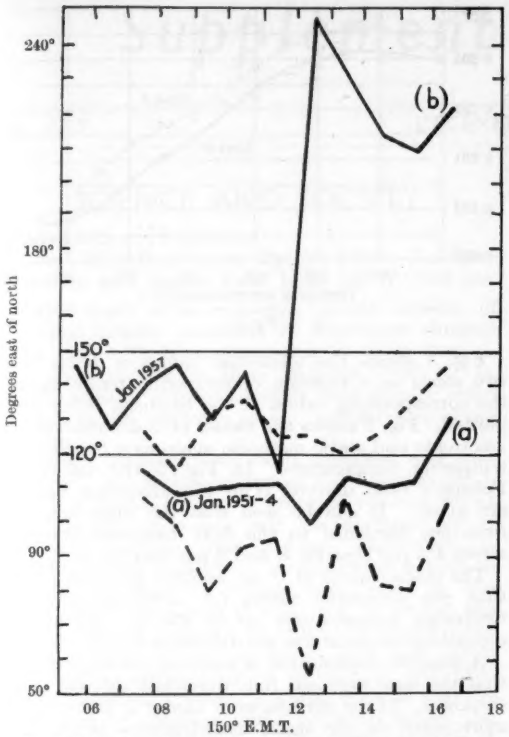

Fig. 1. Diurnal variations in direction of travelling ionospheric disturbances: (*a*) January 1951–54 (pecked curves show extreme values); (*b*) January 1957

activity in 1954, and which had already reached a record high value in the (southern) summer of 1956–57.

The assistance of the staff of the Sydney Section in collecting and processing these observations is gratefully acknowledged.

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Radio Noise from Planets

The reception of high-frequency radio noise from the planets Jupiter and Venus[1–3] has led to speculation on the nature of the causative disturbances. One suggestion is that the noise originates in electrical discharges analogous to terrestrial lightning, and Kraus[3], from consideration of the total energy in lightning discharges, has concluded that a source on Venus, of comparable size to those on Earth, would be sufficient to explain the noise. Before the analogy is pressed too far, however, it is desirable to compare the characteristics of the noise in more detail.

One feature of terrestrial lightning is that while the greater part of the energy, and in particular the electromagnetic radiation at very low frequencies, emanates from the high-current stroke to ground, noise at high frequencies has its origin mainly in discharges in the cloud. These cloud discharges are often associated with ground strokes, but are of different form and much lower energy. Any derivation of the high-frequency radiation from consideration of the total energy of the lightning flash may, therefore, be grossly in error. A more satisfactory basis of comparison is the observed form of high-frequency radiation from terrestrial lightning.

Typical noise from a single flash, as observed in a bandwidth of 500 c./s. at 10 Mc./s., consists of a burst lasting up to one second and of peak amplitude about 1 mV./m. at a distance of five kilometres from the flash. These are approximate figures, but only orders of magnitude are being considered. On this basis a similar flash on Venus would give a burst, received on Earth with a power flux of 10^{-26} watts/m.^{2}/c./s., and the corresponding figure for Jupiter would be 5×10^{-26} watts/m.^{2}/c./s.

The measured amplitudes of the noise bursts from Venus and Jupiter are 9×10^{-22} and $2{\cdot}6 \times 10^{-21}$ respectively, at 27 Mc./s. (ref. 3 and private communication from J. D. Kraus). Since a terrestrial atmospheric would have lower power at 27 Mc./s. than at 10 Mc./s., perhaps by a factor of ten, the discrepancy between the measured noise power and that which would be expected from a flash of terrestrial form is of the order of 10^6 and 5×10^7 respectively for Venus and Jupiter.

It must be considered, however, that lightning flashes on Earth do not occur in isolation; it has been estimated that about one hundred flashes per second take place over the world as a whole. Since each disturbance lasts an appreciable fraction of a second, the fields are superimposed, and the total field at a distance may greatly exceed that from a single flash. It is reasonable to assume that a similar state of affairs would exist on the other planets, and this may be a partial explanation of the amplitude discrepancy, particularly for Jupiter, where the storm areas might be much larger than those on Earth. However, it seems necessary also to assume that the scale of the disturbances greatly exceeds that of terrestrial discharges, or that they are of different form, with much more high-frequency energy, or that some form of focusing takes place.

If the noise originates in a multiplicity of storms, its character is difficult to understand. To an observer in outer space, terrestrial noise would be continuous, owing to the integrated effects of a large number of storms. The noise from the planets is reported to consist of bursts, with durations similar to those of typical atmospherics from single lightning flashes. Before the analogy with terrestrial discharges can be accepted, an explanation for the occurrence of discrete bursts must be found. Perhaps these bursts are introduced by fluctuations in the condition of the propagating medium rather than in the activity of the source.

The atmospheric noise observations on which these remarks are based are part of the programme of the Radio Research Board, and this communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

F. Horner

Department of Scientific and Industrial Research,
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Variation of Elastic Constants of Hardened 1 per cent Carbon Steels on Tempering

It was shown some years ago that changes in elastic constants accompany the hardening process in steel[1] and can be measured by ultrasonic techniques. More detailed experiments have been made recently on two commercial steels containing about 1 per cent carbon. The steels were quenched in oil from 780° C. and then tempered for one hour at temperatures between 100° C. and 650° C., in steps of 50° C. Young's modulus, E, and the rigidity modulus, G, were measured after each heat treatment by the ultrasonic-pulse method. The rigidity modulus was also measured by static loading, the same specimens being used.

The specimens were 7 in. long and 0·5 in. in diameter with enlarged ends of square section for the application of the static torque. The square ends were used for the ultrasonic tests in which the phase velocities for pulses in the longitudinal and transverse modes were measured. The values of E determined from these velocities are estimated to be accurate to within ± 0·2 per cent and those for G to be within ± 0·1 per cent.

The static values of G were measured in a special rig designed to apply a pure torque and the maximum shear stress did not exceed 4,000 lb./in.². The twist was measured over a length of 3 in. by means of two mirrors which were observed simultaneously with an autocollimator. The static values of G are considered to be accurate to within ± 0·3 per cent.

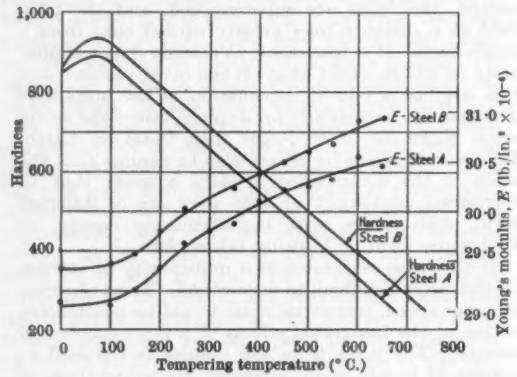

Fig. 1

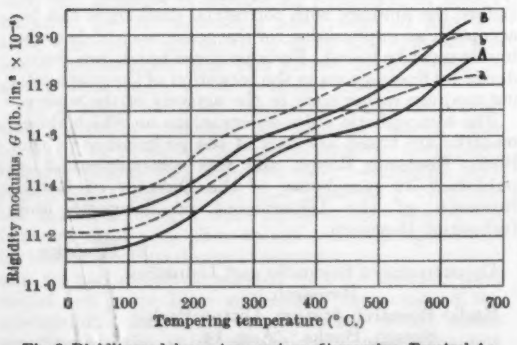

Fig. 2. Rigidity modulus vs. temperature of tempering. For steel *A*: (*a*) by the ultrasonic method, (*A*) by the static method; and for steel *B*: (*b*) by the ultrasonic method, (*B*) by the static method

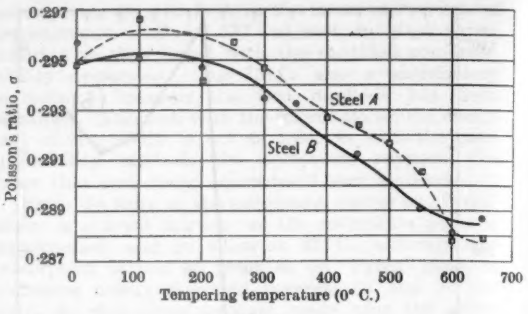

Fig. 3

Fig. 1 shows the ultrasonic values of E for the two steels as a function of tempering temperature, the corresponding values of the hardness being also plotted. Fig. 2 shows the values of G determined by ultrasonic and static methods, again as a function of tempering temperature. In Fig. 3 the values of Poisson's ratio derived from the ultrasonic figures are given. It can be seen that the total increase from the hardened to the fully tempered state is about 4·5 per cent for E and 6 per cent for G.

The static values of G are about 1 per cent lower than the ultrasonic values for hardened steel for tempering temperatures up to 450° C. At higher tempering temperatures the difference is insignificant.

A possible explanation is based on the supposition that the bars were not fully quenched through their thickness. If the surface were harder it would have more effect on the static measurements because of the stress gradient, whereas the ultrasonic tests are based on the average wave velocities in a radial direction. Further work would be needed to prove the validity of this effect.

This work has been carried out as part of the research programme of the National Physical Laboratory and is published by permission of the Director.

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A Surface Electroluminescence Effect in Diamonds

Ten diamonds, all of type I, have been found to luminesce with bright green spots of light when a potential difference is applied to them. The luminescence is often intense enough to be seen in daylight. This effect was first noticed while investigating some aspects of the counting properties of the diamonds, and only after the diamond had been coated with a thin layer of graphite and annealed in this condition.

All the stones so far tested are of the conventional rhombohedral form and with a maximum dimension of about 1 mm. Before being coated with 'Aquadag', the diamonds were good insulators with a resistance greater than 10^{12} ohms: after coating, the resistance between opposite faces fell to 10^{6} ohms or thereabouts.

(*Continued on p.* 1271)

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SCIENCE AND SOCIETY

The Poverty of Historicism

By Prof. Karl R. Popper. Pp. xiv+166. (London: Routledge and Kegan Paul, Ltd., 1957.) 16*s.* net.

THIS book is an enlarged, revised version of some articles published in *Economica* thirteen years ago. Their reappearance in book form is very welcome, for in these writings Prof. K. R. Popper adds to the considerable debt already owed to him by all students of the natural and social sciences.

Popper's intentions are both polemical and constructive. He wishes to expose the fallacies which underly a certain theory, or group of theories, about both the subject-matter and the methodology of the social sciences. This doctrine, 'historicism', is roughly that the task of the social sciences is both to discover the 'laws' or 'trends' exemplified by the development of societies in time, and to predict the future course of history. In criticizing this, Popper makes a large number of illuminating and subtle observations, particularly in connexion with the crucial difference between a trend, such as may be established by statistics, and a universal law, of the kind desiderated by physics. This logical analysis of laws and theories in physics is not only of considerable importance in its own right, but it also conclusively shows that there can never be a holist or historicist 'science of society'. As against this, Popper defends a piecemeal approach to both social investigation and reform; this he calls "social engineering"—a phrase with unfortunately mechanistic overtones, which, however, Popper is at pains to disavow.

There are three topics whose treatment by Popper is, I think, open to question.

(1) The notion of historicism is qualified in so many ways that in the end the term has a very wide meaning indeed, perhaps too wide to be very useful. Historicism, we are told, is both the theory that large-scale social changes can be predicted, and that they can be controlled. As Popper shows, predictability and controllability are not the same, and so we have two distinct varieties of historicism. Further, a distinction is drawn between what are called pro-naturalistic historicists, who regard the methods and objectives of the social sciences ('social dynamics') as essentially the same as those of the natural sciences, and anti-naturalistic historicists who reject this on the grounds that the complexity of society vitiates the experimental method, and that historical development precludes generalization. This gives us a fourfold classification of types of historicism, and there are doubtless others, for Marx, Plato, Comte, Spengler, Toynbee, Mill and Mannheim are all said to be, in their various fashions, historicists. However, the reason why Popper gives to 'historicism' such a wide meaning is that he very properly wishes to state these theories in their most plausible form before setting out to demolish them.

(2) According to Popper, the essential difference between the natural and social sciences is that the latter permit the adoption of a method of logical construction in which a model of behaviour is set up on the assumption of complete rationality on the part of the individuals concerned, so that we can estimate the deviation of actual behaviour from model behaviour by using the latter as a zero co-ordinate. This technique, which in this application is derived from Weber's *verstehende Soziologie*, is of great importance in the social sciences; but the employment of this type of idealized model is also important in the natural sciences, although admittedly here no reference is made to rationality. There seems no difference in principle between, for example, an economist's use of the concept of perfect competition and a physicist's employment of the notion of 'free motion' in a Newtonian system.

(3) In discussing the conditions of scientific and technological progress, Popper rightly insists that the scientific community is a social institution whose standards of objectivity make possible the growth of science. He associates this with a different doctrine which, although widely accepted, is in my view both mistaken and dangerous—it is that "science is based upon free competition of thought; that is, freedom" (p. 159). In fact, the only social requisite for the development of science is free interchange of ideas *on scientific issues*; this might co-exist with complete absence of freedom in respect of other matters. Although liberal humanism made the sciences possible, we cannot assume that it is essential for their preservation. This supposition is one of the reasons why it is still difficult for many to recognize the achievements of Soviet science. We can all think of individuals who combine scientific sophistication with political superstition, though to what extent a whole society can succeed in maintaining the departmentalization is a question that cannot as yet be answered. But its answer must not be begged.

It would be misleading, however, to conclude on a critical note. This is an important and original book which makes valuable contributions towards the solution of a number of difficult and fundamental questions.

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ARCHÆOLOGY AND THE BIBLE

What Mean These Stones?

The Significance of Archæology for Biblical Studies. By Prof. Millar Burrows. (Meridian Books.) Pp. xvi+306. (London: Thames and Hudson, Ltd., 1957.) 12*s.* 6*d.*

THE Bible is a library of books, not all of the same literary or historical importance. In some cases (especially in the Old Testament) the books themselves are composite and contain ancient frag-

ments embedded in a more recent framework. When, therefore, Prof. Burrows suggests that archæological researches in Palestine back up statements appearing in the writings, it must be clearly understood that in no sense can the verbal accuracy of the whole be demonstrated; all that can be said is that many topographical descriptions can be shown to be reasonably correct, and some of the ideas underlying the outlook of the people can be shown to be in agreement with the written records. Prof. Burrows knows his material and is not at all one of those verbal inspirationists who still hanker for proof that every word of the written text is a scientifically accurate statement. The only fault in his book—and for some of us older folk it is a real one—is the small print. Why the publishers did not produce a better and larger volume I cannot imagine.

Prof. Burrows first discusses what archæology can teach us and how its finds must be interpreted. He then deals with the texts. He continues by trying to show how far in the long story of Israelite development the archæological evidence seems to reinforce the written accounts. The last chapter deals with the religious and ethical background. In this connexion it can be recalled that some of the patriarchal legends and indeed the beginnings of an ethical religion seem to have already been evolved in the Bronze Age Ugarit Kingdom of northern Syria long before the Hebrews infiltrated into Palestine. It would appear that when Egypt was strong she kept open the high road to Damascus whence came her supplies of wood. When Egypt was weak, Canaan was controlled by a number of cities which organized the defence of the countryside. With the arrival of the Pharaohs of the eighteenth dynasty these cities were destroyed and the great road re-opened. During the times of the 'Heretic King', once again the Egyptians retired and the road was blocked. But owing to the recent destruction of the cities the countryside could not be defended. It was just then that the Israelites infiltrated into the region. Only Jericho (destroyed by an earthquake similar to that which in 1927 caused the banks of the Jordan above Gilgal to cave in and so ponded back the water for a few days—permitting the invaders to cross dryshod) and Ai (obtained by fraud) were taken, but the countryside was occupied; and this because the Pharaohs of the eighteenth dynasty had first destroyed the ruling towns and then left the country. Now turn up Joshua xxiv, 12: "And I sent the hornet before you, which drove them out from before you...". The symbol of the Pharaohs of the eighteenth dynasty was a winged wasp! Just a sentence of real history. M. C. Burkitt

ROMAN ROADS

Roman Roads in Britain

By Ivan D. Margary. Vol. 2: North of the Fosse-Way—Bristol Channel (including Wales and Scotland). Pp. 288+24 plates+6 maps. (London: Phoenix House, Ltd., 1957.) 50s. net.

THIS is the second and concluding volume of Mr. Margary's survey of the Roman road system of Britain. The first volume was very generally and rightly acclaimed by Sir Mortimer Wheeler, for we have had to wait nearly half a century for anyone to take up the heavy task of bringing Codrington into line with the modern knowledge of this subject (see *Nature*, 176, 3; 1955).

It is a curious fact that although the Roman road system of Britain has attracted the almost passionate attention of antiquaries for more than two hundred years past, the subject still awaits really adequate treatment. On various occasions of late, when research projects in archæology have been discussed, a systematic study of our Roman road system has been proposed, always in vain. Now this would certainly be a very large project which could only be undertaken on a team basis, and it would be hampered by the fact that a good proportion of the system in Britain is buried under modern roads. All the same, there are many hundreds of miles of road quite free of modern encumbrance, but it is still only occasionally and locally that we can speak with knowledge derived from actual testing in the field about the width of the road, its composition, its ancillary features, and its date within the period.

We cannot expect this information from Mr. Margary, for he is but one man, and here collates for us all that is known. He has himself shown the way in his own more detailed researches into the Roman road system of the Wealden region. But the whole field of British archæology can show no more really comprehensible subject than this, provided that enough properly organized work is done. It may be objected that the time is not ripe for such a project even now. It is certainly true that the full tale of Roman roads in Britain is far from being made up, as Mr. Margary will be the first to acknowledge, as exemplified by the appendix to this volume which records progress in this field south of the Fosse Way–Bristol Channel line in the short time since his first volume appeared. It becomes more evident every year that the network of properly constructed and maintained Roman roads in Britain is far greater than we suppose. It is possible for important links in the system, like the roads connecting Silchester with St. Albans and Gloucester with Bath, to be only appearing now, as Mr. Margary's study sees the light, and it would be rash to prophesy what will come out of Wales and the Midlands in the next decade.

Roads, whether they are Roman or of later date, make a coherent system in relation to the population pattern of their time. In the case of several parts of Roman Britain, and in particular the Midlands, this pattern is now beginning to take more definite shape and density in areas which used to be almost blank, and the recognition of many lesser roads there is following suit. The need now is for a study section by section of every Roman road in the country, which will establish the exact line, the date of construction and of any major modifications, the make-up of the road with reference to local and other materials, the engineering features of difficult tracts, all recoverable information about bridges, viaducts, and culverts, and, last but not least, the related human settlements, whether actually on the line of the road or in the more immediate region through which it passes. There is also the important question of survey methods used in the lay-out of the original line.

In some parts of the country, notably in East Anglia, there is reason for believing that some roads were of only temporary military importance, while others were more enduring and related to the devel-

oped economic and administrative life of the regions through which they pass. Here once again Mr. Margary has shown the way with his Wealden studies; but the process requires extension to the whole country. Locally the details of suburban roads and by-passes in relation to towns also need more intensive study where conditions still permit this.

Therefore, while we welcome the completion of Mr. Margary's great task and applaud the skill which he has shown in handling and presenting a great body of material in convenient form, it must be made plain that this is not the end. These two volumes come at a time of growing public interest in archæology. They are passing into the hands of a wider public than was the case of archæological books even twenty years ago, and they will certainly play a great part in promoting this long-established line of study. They are at once a landmark and a point of departure.

C. W. PHILLIPS

THE ESSAYIST OF THE BRITISH COUNTRYSIDE

Field and Farm

Essays now First Collected, with some from MSS. By Richard Jefferies. Edited with an Introduction and Notes by Samuel J. Looker. Pp. 191. (London: Phoenix House, Ltd., 1957.) 15*s.* net.

RICHARD JEFFERIES was one of the most highly gifted writers about the English countryside in the whole of our history. He was born in 1848 at the little village of Coate near Swindon; his father was a small farmer, unpractical but a keen observer of Nature and natural phenomena, and also a great reader with a considerable library of the best authors. He introduced Richard to Homer, interested him in the neighbouring Roman encampments, and trained him in the habits of the naturalists. Richard did not, however, follow his father on the farm, but at the age of seventeen became reporter for a local paper and afterwards joined the staff of the *Wiltshire and Gloucestershire Standard*. Some twelve years later he moved to Surbiton and became a free-lance journalist, writing articles on the countryside for *The Times*, the *Pall Mall Gazette*, and some of the agricultural journals, especially the *Live Stock Journal*. He also wrote three indifferent novels and other books which were not all appreciated. Two, issued by Longmans, "The Story of my Heart" (1883) and "Red Deer" (1884), had been failures; Longmans consequently refused "The Life of the Fields", which, however, was later published. "Amaryllis at the Fair" was rejected by Bentley but afterwards accepted by Sampson Low (1887). His clientele was highly esoteric.

Jefferies started collecting his scattered writings into volumes but died before the task was completed. Many would have been lost; they were mostly unsigned or were under a variety of pseudonyms, and no complete list could be found. By prodigious efforts, for which all admirers of Jefferies must be profoundly grateful, Mr. S. J. Looker has unearthed a number of them. He issued some in 1948 under the title "Chronicles of the Hedges" and now a further group in this volume, "Field and Farm".

The essays are short, compact, full of close observation and very attractively written. They cover one of the most interesting periods in the history of the British countryside, the 1870's and 1880's, when the brilliantly successful golden age of British farming was giving place to the terrible depression that lasted until about 1900, and his vividly recorded reminiscences of older people take the story back into the period when farms and villages were largely self-contained and had little personal contact with the outside world. It was the milk traffic with London that first brought news-sheets—weeklies, not yet dailies—into his country: the most popular items were local squabbles, slashing attacks on established institutions, murders and other crimes spicily related. He tells of other new troubles: of town trespassers breaking farm fences, trampling down crops, and allowing their dogs to chase sheep; except that there is no mention of litter, all this might have been written to-day. He is heavily down on some of the newfangled innovations: the newly introduced lunch which broke up his day and spoiled his dinner, the "heathenish Tories" with their Primrose League seducing the villagers, the parson that refused burial to a Nonconformist baby, and the growing power of money.

Most of his writing, however, is about the common things of the countryside: the birds, the flowers, the trees and the fields. His descriptions are not simply accurate—for he was a sound observer—they are expressed in delicately appropriate language conveying something of the elusive beauty of the things he saw. He was essentially a solitary figure, spending his years, especially the later ones, not in the quest for personal advancement but in communing with Nature, trying to see beyond the mystery of which he was conscious and yet could never penetrate; it is this that gives the special quality to his writings.

His last five years were darkened by illness: he died in 1887 at the age of thirty-nine. He lies buried at Broadwater, Worthing, near W. H. Hudson, the one who comes nearest to him in quality though writing a little later in time. Mr. Looker is to be congratulated on his discovery of these essays, and the Phoenix Press on presenting them so well.

E. JOHN RUSSELL

INSTINCT IN MAN

Instinct in Man in the Light of Recent Work in Comparative Psychology

By Dr. Ronald Fletcher. Pp. 248. (London: George Allen and Unwin, Ltd., 1957.) 40*s.* net.

THERE seems to be a pendulum-swing in our thinking about some of the more general aspects of human behaviour. At one time they are regarded as a product of biological forces inherited by every member of the species; at another, the environment is held to be all-powerful.

During the past thirty years or so we have moved out to the environmental extreme. Even in the clinical field, where the biologically oriented theories of Freud have gained wide acceptance, the part of psychoanalysis that has been most influential relates to the effects of the early environment. The pendulum is now beginning to swing back.

Recently the ethologists, Lorenz, Tinbergen, Thorpe and others, basing their studies mainly on animal behaviour, have shown that instinct is not

an outmoded concept, and may even be of value at the human level. In so doing they have confirmed, as well as improved upon, the pre-1920 work of Lloyd Morgan, McDougall and Drever.

Dr. Fletcher has given a general account of the whole cycle, with particular reference to the systematic importance of the biological approach to the sociologist. The treatment is discursive but readable. It suffers from a lack of first-hand experimental or clinical experience and from a rather amorphous theoretical background. On the other hand, it is important that social scientists should have brought to their notice once again evidence from animal behaviour which they might tend to neglect. It is also of value to have put into historical perspective for the first time our recent thinking on some aspects of motivation.

J. Drever

SIDELIGHT ON A MODERN ARCTIC EXPEDITION

High Arctic

The Story of the British North Greenland Expedition. By Mike Banks. With four chapters by Angus Erskine. Pp. xii+276+17 plates. (London: J. M. Dent and Sons, Ltd., 1957.) 25*s*. net.

THIS book is good evidence of the truth that, if we are to get something approaching the whole story of a major expedition, it is necessary that several of its members should contribute individually to the written record. To a reviewer, himself a survivor from Antarctic exploration half a century ago, this has been a fascinating book to read, far more so than could be any carefully edited official narrative. Its interest is much enhanced because it is, in effect, the work of two authors, differing in temperament and experience and both conveying their experiences in an uninhibited manner. To one who has himself written in an amateur way on psychological aspects of polar exploration, it is particularly intriguing to be given a glimpse of the old pattern repeated under such very different conditions: alternations of exhilaration and depression; the formation of cliques; the deepening of loyalties and prejudices—all the kaleidoscopic responses to team life in a harsh environment can be detected, substantially unchanged in spite of the impact of radio and the application to polar exploration of mechanical aids and air support.

The more isolated Antarctic sojourners even of to-day will envy the variety provided by the more prolific Arctic flora and fauna; the contact with trappers and the men of the Danish patrol (even at the expense of an occasional parking fee) and American airmen dropping, among other things, condemned pork and hamburgers for under-privileged dogs. Survivors from a past less-sophisticated age will be impressed by the increased fire risk caused by the introduction of petrol as an essential of polar travel, especially when combined with the intervention of the 'Commando' type who is trained to live dangerously as a matter of course.

To the non-mechanical mind one of the most amazing and creditable facets of modern exploration is the thousand and one improvizations successfully carried through in the maintenance of 'weasels' and their like in the field. Mike Banks's remark "on rough going give me my flat feet" is a modernized version of McClintock's fiat that set the pattern of sledging technique for the Scott and Shackleton expeditions. One thing very different from their regime is the much more lavish use of alcohol nowadays, which perhaps reflects the Service habits of a more indulgent and less disciplined age than those of Victoria and Edward VII. It is arguable that, in this particular respect, the old practice had more to recommend it both from the physical and psychological points of view. There is some piquant phraseology here and there, of which as examples I would choose two references to the "white-out" which has become so important since aircraft are used: Angus Erskine's description "like the inside of a ping-pong ball" and that of the observer who looked out of a tent and could see "two-fifths of one-third of dam-all".

Raymond Priestley

CHEMISTRY OF SIGHT

The Visual Pigments

By Dr. H. J. A. Dartnall. Pp. vii+216. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1957.) 30*s*. net.

IN 1878 Kühne published his classic treatise on visual pigments. The same year, it appeared in England in a translation by Michael Foster entitled "On the Photochemistry of the Retina and on Visual Purple". Kühne's book laid the foundation for much that has since been learned about visual pigments. The intervening years have, however, brought many new discoveries—the elucidation of the role of vitamin A in vision, and hence nightblindness; the discoveries of retinene, and of vitamin A_2 and retinene$_2$; the characterization of several new visual pigments; and many others. Dr. Dartnall has successfully met the challenge of writing the first book on visual pigments since Kühne. He is an authority on the chemistry of visual pigments, and his book fills a need which has long been felt by teachers, students and research workers in the field of visual physiology.

The book starts with a description of methods of preparing visual pigments and of measuring their absorption properties. It goes on to a classification of visual pigments and a discussion of their chemical reactions, particularly the intermediates and end-products of bleaching. Dartnall next discusses the physical chemistry and photochemistry of rhodopsin, and reviews critically proposed structures for the rhodopsin chromophore. A chapter is devoted to the *cis–trans* isomerism of the retinenes and vitamins A in relation to the chemistry of the visual pigments, and another to methods which test the homogeneity of various preparations of visual pigments. A final chapter summarizes the interesting results obtained recently from the study of visual pigments in visual cells *in vitro* and in the living eye. Each chapter ends with a list of references. The book can therefore be read as an integrated introduction to the field, or as a series of semi-independent reviews. It will be useful to the general reader as well as to the person interested in some specific aspect of the field.

A number of minor errors have inevitably crept into the condensation of such a wide range of information into about two hundred pages. Thus the discussion of resonance (p. 101) reveals a misunder-

standing of the concept of the hybrid bond. There is also some trouble involving terminology. For example, Dartnall uses the term' isorhodopsin' in two senses, sometimes in the same sentence (as on p. 53), to denote 'regenerated rhodopsin', now known to be a mixture of two molecular species (the sense in which the term was originally proposed by Collins and Morton); and for the specific pigment formed by the combination of the iso-*a* isomer of retinene$_1$ with rod opsin (the sense in which the term is currently used). More serious errors are contained in the summary diagram on p. 54. Such diagrams are potentially more instructive than several pages of text. It is unfortunate that this one contains hypothetical and actual reactions mixed in a way which is likely to mislead readers unfamiliar with the details of the field.

A final word on the extraction of visual pigments. The methods given in this book have on the whole not yielded the purest preparations of visual pigments. Dartnall therefore describes various ways of correcting for coloured impurities. Unfortunately the preparation of pure visual pigments is still something of an art. However, in general, carefully purified visual cells yield spectroscopically pure solutions of visual pigment, which need no further correction; while visual cells contaminated with other tissue debris yield impure visual pigments. Since paper and pencil corrections introduce errors as often as they eliminate them, every effort should be made to prepare solutions of visual pigment which are sufficiently pure to need no correction. Such preparations are being made in several laboratories by methods which should have been included in the present volume.

However, these are minor criticisms of a book which offers excellent discussions of the photochemistry of the visual pigments, their synthesis, and their possible role in stimulating vision. The biochemistry of vision is a rapidly growing field, and it is unfortunate that Dr. Dartnall's review spent two years in press. I hope that author and publishers will give us a second edition in the near future.

RUTH HUBBARD

COAGULATION OF BLOOD

Human Blood Coagulation and its Disorders

By Dr. Rosemary Biggs and Dr. R. G. Macfarlane. Second edition. Pp. xxv+476+3 plates. (Oxford: Blackwell Scientific Publications, 1957.) 42*s*. net.

TO write a reasoned and critical account of the present status of our knowledge of the mechanism of hæmostasis and of the disorders to which it is prone is a Herculean task which few people would care to undertake, and fewer still possess the breadth of view of the subject to enable them to bring such a task to a well-balanced conclusion.

The unequivocal demonstration of the separate existence of factor V and of the general mode of its action by Owren in 1947, closely followed by two other groups of workers, initiated a period of intense activity in the subject of blood coagulation which may only just be levelling off. In 1949–50, nearly 400 papers were published in the field and in 1953–54, when the first edition of this book appeared, the number had risen to 600. The deceptive facility with which experiments on blood coagulation can apparently be conducted has always led to the publication of much ill-considered work, and excessive labour has consequently to be expended to winnow the few grains of truth from the chaff. Latterly in addition, as well-authenticated new components of the clotting mechanism have come to light more or less simultaneously in different laboratories, a multiple nomenclature has arisen further to complicate efforts to appraise the significance of any particular piece of research.

It must have been the cause of considerable chagrin to the authors to find that the first edition of this book was out of date almost immediately after it was published, chiefly on account of developments arising from their own work. The situation was a result of their demonstration in 1953 of the essential mechanism of production of the powerful intrinsic thromboplastin of blood. This was previously believed, erroneously, to be very weak in comparison with thromboplastic extracts of tissues, on account of an unrecognized lag phase in its production. As the book was in the press it at last became clear that clinically recognized hæmophilia could be due to the deficiency of either of two factors now known to participate in intrinsic thromboplastin generation; these are variously referred to, but in the authors' terminology are called antihæmophilic globulin and Christmas factor. There may be other factors, a deficiency of which can evoke a syndrome similar to hæmophilia, but these two alone are established beyond reasonable doubt.

The revision of the book is consequently mainly concerned with the newer knowledge of the components involved in the generation of intrinsic thromboplastin in blood, the probable mechanism of their interaction and the consequent modification necessary to the classical theory of blood coagulation. The development of the thromboplastin generation test has facilitated both diagnosis and treatment of hæmophilia and Christmas disease, and it has further implications.

Naturally the other chapters of the book have been brought up to date. It would appear that the conception of the function of factor VII in the coagulation system is altering; also new mechanisms have been put forward to explain the activation *in vitro* of plasminogen, though the evidence for these does not appear to be definitive.

The book is written essentially from a physiological–pathological point of view. Lest the impression has been given that its only concern is with the blood coagulation mechanism, it must be stated that the overall aspects of hæmostasis are also discussed in relation to platelets and capillary phenomena.

An extensive account is given of the various tests which may be applied to detect deficiencies of the clotting function, and in appendixes adequate details are provided for the laboratory preparation of reagents required.

It is distressing to find a book of such high scholarship marred by faults of production. There are many misprints in the text, and a large proportion of the numerous graphs give the impression of having been drawn on blotting paper. The reviewer found it irritating also to have the bibliography in two sections, one comprising the references of the first edition and another an addendum of references to papers published from 1953 onwards.

In view of the emergence of a phase, mentioned by the authors in their preface, in which more disciplined biochemical work will be necessary for the further

advancement of the subject, they might perhaps have given more consideration than they have to the established work in this field.

Though there is still room for considerable variation of opinion in the interpretation of some of the experimental findings, there is no doubt that all who are interested in the subject of blood coagulation will be indebted for many years to come to the authors, for the clarity and wisdom with which they have compiled this comprehensive and most readable monograph.

R. A. Kekwick

PLANT DISEASES AND HUMAN WELFARE

Principles of Plant Pathology

By Prof. E. C. Stakman and J. George Harrar. Pp. xi+581. (New York: The Ronald Press Company, 1957.) 8 dollars.

THE names of Prof. E. C. Stakman and Dr. J. G. Harrar are in themselves almost guarantee enough that this would not be just another academic text-book, but the fact could well have been emphasized by a title more appropriate to their vivid treatment of the subject. "Principles of Plant Pathology" tends to imply dull reading, of the sort needed to pass examinations, whereas there is nothing dull about this book. The student who has to pass examinations in plant pathology will certainly find much here to help him with this chore, but this is a minor part of the book's value. What is much more valuable is that he will soon realize that he has entered a subject of immense and varied scientific interest, the fascination of which is surpassed only by its economic and sociological importance. A better title, however, is less needed for plant pathologists, for whom the book will be essential reading anyway, but to attract the wider audience that could read much of it with interest and profit.

Its style, theme and contents are most simply illustrated by a few quotations. "Man occupies this planet as a guest of the plant kingdom." "Unless plant diseases are contained, the world's efforts to feed itself cannot be successful." "This problem is by its very nature international in scope." "The health of plants is vital to society and human progress, and this volume is essentially a discussion of the problems and principles involved in protecting the health of domestic plants." The only comment called for is to say that the discussion is excellently conducted and the conclusions amply justified.

Prof. Stakman and Dr. Harrar show that much has been achieved in the short history of plant pathology, but they make it equally clear what a lot still needs to be done before the world's crops reach even a moderate state of health. Their unique international experience, first at the famous school of plant pathology in Minnesota and later through the Agricultural Division of the Rockefeller Foundation, allows them to write with equal authority on present and future problems. Although they have no doubt that what needs to be done could be done, they are far from complacent; indeed their awareness that present research is inadequate gives an impelling sense of urgency to much of their writing. Food is far from plentiful in some parts of the world, mainly those where losses from pests and diseases are greatest, and with human populations increasing rapidly, more than is now harvested is soon going to be needed everywhere. There is some comfort to be gained from the fact that man need not starve provided he stops sharing his crops with pests and diseases; but the reaping of full instead of part harvests will not come about automatically. Those responsible for deciding what proportion of scientific endeavour should go to different subjects seem often not to put first things first, and biology tends to become an increasingly poor relation of other sciences. To reach the Moon may be a laudable ambition, but its fulfilment will butter no parsnip, and surely it should wait until both the Moon visitors and those left on Earth are assured of enough to eat. This assurance will not be gained unless agricultural research is much increased. The cost would be small, not only in relation to the gains, but also relative to what is spent on less essential problems.

But this book is far more than an eloquent plea for increased research. It deals adequately with all kinds of diseases, and describes the conditions that affect their prevalence and how they can be combated. Considering its scope, it contains few errors, and these on minor matters that do not affect the general conclusions. The text is matched by many excellent photographs, and the whole book is finely produced. Each of the eighteen chapters has a selected list of references; there are three appendixes listing books on plant pathology and the principal pathogens and insects cited in the text, and there are a subject index and an index of names.

F. C. Bawden

LAVOISIER'S LETTERS

Oeuvres de Lavoisier

Correspondance. Recueillie et annotée par René Fric. Fascicule 2: 1770–1775. Pp. 251–536. (Paris: Éditions Albin Michel, 1957.) 2,750 fr.

THE second fascicule of Lavoisier's correspondence covers the years 1770–75, one of the most interesting periods of his life in which he was beginning his investigations into the phenomena of combustion. This volume contains 160 letters and documents, seventy of which are by Lavoisier himself. They give an intimate picture of his varied interests in these years and, thanks partly to the biographical footnotes, of the personalities with whom he was in contact. However, the most important and fascinating documents are a number of Lavoisier's own drafts of his notes and letters which reveal the meticulous care that he took in their composition.

Of the thirty-seven letters written in 1770, twenty-six deal with Lavoisier's responsibility as a 'farmer-general' for administering the control of the processing and sale of tobacco. Most of them were written to his father-in-law Paulze, under whose direction he was working, and they show Lavoisier's conscientious devotion to the details of his task and his efforts to prevent the adulteration of tobacco. His shrewd comments and his appraisals of the characters of his officials show his sound business acumen. During his annual tour of his district he reported almost every day on what he had seen and done.

One of Lavoisier's earliest interests had been the improvement of the water supply of Paris, and some of the letters of 1770 deal with this and with a comparison of the efficiencies of the primitive steam

engines used to pump water in Paris with those used in the supply of water to London.

There are only eleven letters dated 1771 and they are mainly concerned with the geological atlas of France in which Lavoisier was assisting Guettard. They show the active interest that he was still taking in this project and how much thought he was giving to geological problems. Geikie said of him that he might have become one of the great founders of geology if he had not given himself up to chemistry.

The early letters of 1772 again deal mainly with geology, but on August 31 Lavoisier, writing to an unknown correspondent, tells him of his unanimous election by the Academy as an *associé chimiste* in the place of Macquer who had become a *pensionnaire*. It was a prophetic change in Lavoisier's life, as ten days later his first experience of burning phosphorus led to the investigation described in the first note to the Academy, which he deposited with de Fouchy on October 20. His second note, which was deposited with the Academy on November 1 and opened and read on May 5, 1775, is reproduced in facsimile in this volume. It contains a brief statement of the 'discovery' that the gain in weight of sulphur and phosphorus during combustion is due to the fixation of a large quantity of air.

In the previous July he had received through Trudaine a letter from Magelhoens (Magellan), a son of the Portuguese navigator, who was living in London in close touch with British scientists. It describes a number of investigations of fixed air (carbon dioxide) and gives an abstract of Priestley's proposal to the Admiralty for its use in making mineral waters. This was the first of a series of letters from Magelhoens to Lavoisier, who sent him from time to time copies of Priestley's papers.

There are only four letters dated 1773, perhaps for the very good reason that Lavoisier's time was almost entirely occupied with his study of the evolution of gases during chemical reactions and with careful analysis of the results of previous investigations. Lavoisier's account of the work was published in a separate volume "Opuscules Physiques et Chimiques" in January 1774. He sent copies to a number of learned societies and fortunately the drafts of some of the letters that accompanied them have been preserved.

The first two were addressed to the Royal Societies of London and Edinburgh with copies for Priestley and Black. The letter sent to the Royal Society acknowledges his debt to British chemists: "Cest dans le Sein de langleterre que la doctrine de la fixation de lair dans le Corps a pris naissance. . . ." The letter to Edinburgh shows his realization of the debt he owed to Joseph Black, and his conviction of the importance of the line he was following: "Cest dans votre ville et dans le Sein meme de votre illustre Societié que S'est presquentierement formée une theorie nouvelle qui Semble preparer une revolution dans le phisique et dans le chimie . . ."

Most of the correspondence in 1774 is connected with the publication of the "Opuscules", and later in the year came a letter from Beccaria pointing out that he had anticipated Lavoisier's work on the calcination of tin fifteen years earlier. Lavoisier sent this letter to Rozier to be published with his own paper in Rozier's Journal.

In October of 1744 Priestley had directed Lavoisier's attention to mercury *precipité per se* (mercuric oxide) and in March 1775 Lavoisier deposited a note with the Academy describing briefly his own experiments. It is interesting to compare his original draft with the shortened form in which it was communicated, both of which are printed in this volume. But it was not long before these researches were interrupted by another decisive change in Lavoisier's fortunes. His quick eye had noticed the inefficiency of the operations of the financial syndicate entrusted with the manufacture of gunpowder, to which he had directed the attention of the controller-general, Turgot. A letter from D'Ormesson, one of Turgot's officials, on June 13 informed Lavoisier that he had been appointed with three colleagues to manage the powder factories of France, which also involved responsibility for the collection and purification of nitre. Turgot wrote later to say that lodgings would be provided for Lavoisier in the Arsenal, which was to be his home until almost the end of his life. Lavoisier immediately switched his attention to the urgent problems of his new post, with which most of the later letters in 1775 are concerned.

Undoubtedly Lavoisier must have written many more letters in these years which have been lost or destroyed, so that it is dangerous to generalize from those that have survived. It is strange, however, that there are no letters to his scientific colleagues, except for one to Guyton de Morveau, about the main pre-occupation of his mind from 1772 onwards, his conviction that the investigation of the part played by gases in chemical reactions would solve the riddle of phlogiston and give chemical theory a new basis.

The publication of the correspondence under the ægis of the Academy has had financial support from the University of Delaware and from French industry. Chemists will be very grateful to them for this volume, but it whets one's appetite again for a sight of the as yet unpublished notebooks, without which it is impossible to follow all the twists and turns of Lavoisier's impulsive mind which ended in the chemical revolution.

HAROLD HARTLEY

PLEISTOCENE GEOLOGY

Glacial and Pleistocene Geology

By Prof. Richard Foster Flint. Pp. xiii+553+5 plates. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) £5 net.

IN the preface Prof. Flint states that this book started as a revision of his earlier work, "Glacial Geology and the Pleistocene Epoch", published in 1947; to a certain extent, therefore, some chapters are revisions of that excellent book. So much new work, however, has been done in the years since that volume was written that this book rightly claims to be a new one, bringing his assessment of the various problems up to date.

The book is divided into two major parts of about equal size; the first considers problems of glacial geology, the second deals with Pleistocene stratigraphy. There is one feature of the book which is most helpful: at the end of many sections and chapters there is a short summary underlining the conclusion the author draws from the existing evidence on the point under discussion. In a book of this size, covering such a wide subject, it is more or less inevitable that one interpretation is given greater weight than

other views, but the very full bibliography enables anyone who wishes to evaluate other interpretations to do so, if he is within reach of a good library.

There is a very useful summary of the present state of knowledge on 'frozen-ground' phenomena without the use of the jargon which has tended to grow up around this subject. Prof. Flint deals in Chapter 13 with the problems of fluctuation of lakes in non-glaciated regions; here he takes a world-wide survey and suggests correlations of lake-levels with the various episodes of the glacial advances.

It is perhaps in the second half of the book, the stratigraphical part, that most workers will find what is not to be found easily in other works. After dealing with the special problems of Pleistocene stratigraphy and giving a most useful summary of the history of the nomenclature, he concludes that there is no justification for a Quaternary Period and that the "Pliocene–Pleistocene boundary cannot justifiably have 'system value', but only 'series value'". He would also consider that the Pleistocene series includes all post-Pliocene time.

It is natural to expect that the stratigraphy of North America receives the 'lion's share'; Chapters 18–21 deal with North America. It is most valuable to have his authoritative account of the present state of knowledge of this vast area. The correlation charts given are marked 'tentative', showing that Prof. Flint is far from being dogmatic and realizes that new work will necessitate modifications in the schemes.

The glaciation of Europe is compressed into Chapters 22–23. In these, naturally, the details of the succession in the British Isles can only receive a few pages in each chapter, but those few pages give a clear and fair account of the distribution of the various deposits of the Older and Newer Drifts. Prof. Flint concludes that the evidence shows that in the Newer Drift times the Scandinavian ice-sheet made contact with the British ice off the east coast of England, although Fig. 22–2 does not show it as doing so and this figure and Fig. 22–3 vary considerably on the east coast position of the boundary of the Newer Drift.

The correlation table for the British Isles gives a valuable summary of the position as it is at the present time. This table has been drawn up by Prof. Flint after visiting most of the critical sections and discussing the problems with many workers when he visited England a few years ago. Like the North American tables it is labelled 'tentative'. That the complexities of the British glacial succession can be compressed into about two pages of print and a correlation table shows that Prof. Flint is a master at sorting 'corn from chaff' in glacial matters.

Some may find the chapter on the records of Pleistocene fossils rather disappointing after the masterly summaries of the stratigraphy. The final chapter, on the problem of causes, contains much of interest and the general conclusion reached is that the most hopeful theory is a combination of the effect of uplift with solar variation as the primary cause of glacial periods.

An excellent bibliography, covering thirty-four pages, ends the book. Some of the maps are rather disappointing, the stippling at times is at fault and at others reduction from the original drawings has brought lack of clarity; these are very minor criticisms of a work which should be on the bookshelf of every worker on the Pleistocene. W. B. R. King

QUANTUM CHEMISTRY

Quantum Chemistry

An Introduction. By Walter Kauzmann. Pp. xii+744. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 12 dollars.

THIS is a book on which opinion will be very sharply divided. How this division will be at the deepest level: How should we teach quantum chemistry? Should we regard the mathematical equipment as of such central importance that we must get it clear and thoroughly established before we allow ourselves the pleasure of seeing just how and where it fits chemistry? Or should we think of it as interpreting chemistry to us, and point out to our satisfaction (or perhaps our surprise) that there is an almost perfect correspondence between familiar chemical concepts and (to a chemist) less familiar mathematical techniques? Dr. Kauzmann belongs to the former class of expositors. So this is why it comes about that the first 150 pages are concerned with determinants, operators, matrices and water waves on a hypothetical earth, with never a mention of atoms or molecules or chemical bonds. Chemistry does not really begin until Chapter 11, on p. 375. But by the time that it does begin, we are already familiar with ideas of eigenvalues, quantized functions, degeneracy, perturbation theory, correlation diagrams and other topics.

There is much to be said for this line of attack. It separates the concepts from the techniques, and so simplifies the student's job. But there are things to be said against it: it uses up valuable time, and there is a danger that the characteristic concepts of chemistry are lost in the mathematical formalism. When we read on p. 1 of "chemistry as a branch of mathematics", or on p. 117 that "much of quantum chemistry depends on the possibility of expansions of this kind" (in a complete set), we can see the author's position clearly.

Let it be said at once that he has carried out his policy in an excellent fashion. The book is clear, exceedingly well illustrated, and with a good number of interesting exercises for the student. Further, it manages to include a lot of material not so commonly found, such as nuclear quadrupole coupling, adiabatic and non-adiabatic transitions and chemical shifts in nuclear magnetic resonance, which greatly enhance the value of the book. From time to time, as in the discussion of the relative values of certain exchange integrals, a real physical insight appears, as an aid to understanding the mathematics. But emphasis on the mathematics, while very salutary to those chemists who are given to loose and woolly thinking, does lead to some unsatisfactory points of view, in which there occur "idealizations not capable of experimental verification because of the uncertainty principle"; and an account of resonance in the H_3^+ ion (pp. 378 and 535) which leans so heavily on the classical mechanical analogy that it seems to the reviewer to be not quite correct. Nor will anyone be surprised that one conclusion of the book is that most of the familiar chemical concepts such as hybridization, ionic character, bond energy, valence, are so vague as to be ultimately almost meaningless.

This is not a book for a beginner who wants to pick up his quantum chemistry quickly. But if he has already learnt a good deal of it, this book really will help him to see the essential validity of what he

has been doing, and will warn him of pitfalls. It will also give him great satisfaction in seeing that the mathematics which he needs for his chemistry is not so very dissimilar to that used in other branches of applied mathematics; and at the end he is likely to say that a better title might have been "Molecular Physics".

C. A. COULSON

RÉAUMUR ON STEEL

Memoirs on Steel and Iron

By R. A. F. de Réaumur. (A translation from the original printed in 1722, by Anneliese Grünhaldt Sisco. With an Introduction and Notes by Cyril Stanley Smith.) Pp. xxxiv+396+17 plates. (Chicago: University of Chicago Press; London: Cambridge University Press, 1956.) 45*s*. net.

TWO hundred years ago (October 17, 1757), the death occurred of René Antoine Ferchault, Seigneur of Réaumur, "whose name is to-day widely known only in connection with a thermometric scale and a station on the Paris Métro", to use the words of Prof. C. S. Smith in his excellent introduction to this volume. The main work of his life was his biological researches, and from his investigations on the nests of wasps he might perhaps be regarded as the father of the modern wood-pulp industry. It is, however, as a result of his work on metals, confined to the ten years between 1716 and 1726, that his chief claim to posthumous fame really depends, work from which the malleable cast iron industry directly originated. The volume under review contains the collected memoirs, first of his investigations into the production of steel by carburizing wrought iron, and, secondly, the reverse process, the decarburization of white cast iron, in his attempts to produce steel from that material.

Like so many scientific investigators of his day, Réaumur saw no line of demarcation between the discovery of new knowledge and the putting of such knowledge to practical use, and as a direct corollary of his investigations, which were for the first time strictly scientific, he introduced, although at first somewhat unsuccessfully, a new industry to France and later to the world.

Réaumur lived and worked before the age of modern science; an age which had not divorced itself from the alchemical. His thinking, as is shown throughout this book, still centred on the alchemists' 'salts' and 'sulphurs', and it is a most illuminating example of the way in which a prevailing fashion of thought can blind the researcher to what later would appear to be quite self-evident conclusions—a warning which perhaps is not altogether inappropriate in certain directions even at the present day. In his work on the mechanism of converting wrought iron into steel, for example, he showed beyond doubt that materials, such, for example, as lime or bone ash, which do not contain carbon, have no influence, and that the only constant factor to be found among those which did effect the change was carbon in some form or other. He also discovered, however, that the rate at which the conversion of iron into steel takes place may be accelerated by the presence of a salt. This fact, in view of his habits of thought, so completely blinded him to the obvious conclusion that the difference between the original iron and the final steel lay in the carbon content of the latter, that this, one would have thought, self-evident deduction escaped him completely. It is to the 'salt' as much as to his 'sulphur' that he ascribes the effects observed, a fact which so complicates his thinking both in connexion with carburization and decarburization that the essential simplicity of the processes is completely lost.

Although the age of microscopic metallography was still in the comparatively distant future, Réaumur, with the slender facilities available to him, makes the first serious attempt to correlate structure with properties. The structure he could examine was merely that of the fractured surface, but he repeatedly makes it clear that he realizes that behind what was visibly observable lay some deeper and finer structure on which the real nature of the material ultimately depended. He was, however, able to examine in some detail the effects of carburizing wrought iron and of decarburizing white cast iron, and although the meaning of his observations so frequently escaped him, the idea of a composition gradient was clearly in his mind. He speaks, for example, of wrought iron getting into a condition close to steel. That this involved a process of diffusion he obviously realized, and that the rate of such diffusion depended on the temperature was equally clear. So far as the mechanism of the process is concerned, he appears to have believed that diffusion could produce tiny voids into which the diffusing material passed, a conception strikingly similar to the vacant lattice sites hypothesis of the modern metal physicist. It was inevitable that his work on high temperatures should have led him to consider the nature of heat itself. He knew that different metals had different specific heats, latent heats of fusion, and melting points, but heat to him was still a material phenomenon and he speaks, for example, of the introduction into the sample being heated of "torrents" of particles.

Whether looked at as a contribution to the history of technology or as an account of a most interesting phase in the history of science, there can be no doubt that this book is one of outstanding importance. The translation appears to have been done in an exemplary manner and the editor's introduction could scarcely be improved. To translator and editor, and to the funds made available by the American Iron and Steel Institute, we owe a volume which the publishers legitimately claim to be "the first significant book ever devoted to the iron and steel industry".

F. C. THOMPSON

THE *j* OPERATOR

The *j* Operator for Electrical Engineers

By Philip Kemp. Pp. vii+135. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 21*s*. net.

ELECTRICAL engineers calculate the values and 'phases' of alternating currents and voltages in circuits and networks in very much the same way as they calculate steady 'direct' values, except that the values of the quantities are represented by complex numbers $(a+jb)$. They use j instead of the mathematician's 'i' because they use i for current. The basis for this system lies in the representation of sinusoidally varying quantities by radial lines on a clock-face diagram, referred to as vectors, together with the use

of complex numbers corresponding with the co-ordinates of the ends of these vectors.

The teacher of electrical engineering is faced with the problem of deciding whether he aims at giving his students the aptitude to use such procedures in the kind of problems to which they are usually applied, with just sufficient explanation to make them plausible, or whether, at the other extreme, he proposes to make use of this topic to develop their understanding of the logical basis of the complex number, which can imply uncovering some of the roots of algebra.

Some kinds of student are unlikely to profit if the time available is devoted to any but the more limited aim. Mr. Kemp has chosen to cater for the needs of this class of student and he has done it very well. His book will help many students, provided that they can afford to buy it, to pass the kind of examination that can be passed by obtaining correct answers to numerical problems about alternating currents. The presentation is very simple, clear and logical within the limitations the author has set himself.

The treatment of the j operator as representing rotation through 90° is followed by short chapters on operators representing rotation through 120°, 60° and 30° respectively, leading to a chapter on the 'symmetrical components' of 3-phase systems, making use of the 120° operator. The exponential form of the complex number $A \exp j\theta$ is not mentioned.

The book will be particularly useful to teachers and students in technical colleges. It could have been made useful to a somewhat wider circle if an appendix had been added, to be read by the more mathematically minded, justifying somewhat more rigorously the presumption that the rules of algebra apply to a symbol that is first defined merely as an indicator of a geometrical property.

A. Tustin

THE ELECTRON PHYSICIST'S VADE-MECUM

Tabellen der Elektronenphysik, Ionenphysik und Übermikroskopie

Von Manfred von Ardenne. Band 1: Hauptgebiete. Pp. xvi+614. 74 D.M. Band 2: Randgebiete und Hilfsgebiete. Pp. xii+617–1368. 92 D.M. (Berlin: Veb. Deutscher Verlag der Wissenschaften, 1956.)

It may be thought unusual, if not extraordinary, to say of a collection of data that, once in the hand, it is hard to put down, that it is fascinating, intriguing and (occasionally) exhausting and infuriating. But this is an unusual work and its author no ordinary man. He is Baron Manfred von Ardenne, inventor of some of the fundamental features of high-frequency amplifiers and cathode-ray tubes, the patents from which enabled him before the Second World War to build a private laboratory near Potsdam which eventually included a betatron and other nuclear physics apparatus, as well as some of the best electron microscopes of the time. In 1945 he went of his own accord (so it is said) to work in the Soviet Union, being flown to Moscow with his family and his universal electron microscope. Rumours of his suicide, after shooting the rest of his household, were confounded when he returned to East Germany in 1955 bringing his family and the universal electron microscope back with him—and the manuscript of this extraordinary book. It was intended to sum up "ten years of fruitful research" in the U.S.S.R., most of which had not been otherwise published, and to prepare the ground for the programme of research in his new Institute in Dresden which had been planned from 1951 onwards and was opened in January 1956. As director of the leading laboratory for nuclear and electron physics in the German Democratic Republic, he is now the best-paid physicist in the Western as well as the Eastern Zone. The "Tabellen", in two volumes totalling nearly 1,400 pages, are on the same grand scale as most of his enterprises. They are much more than a collection of tables such as "Kaye and Laby". They are planned as "a concentrated presentation of the essential content [*geistigen Inhaltes*] of the separate special fields in the form of a co-ordinated collection of formulae, tables, literature references and extracts from original papers", on the lines of the pre-war "Gasentladungs-Tabellen" of Knoll, Ollendorff and Rompe. Vol. 1 contains "the most important formulae, fundamental principles, methods, practical designs, results, technical data and properties of materials" relating to electron and ion physics, and electron microscopy. Vol. 2 contains a similar compilation from the related fields of vacuum technique, heat, optics, high-voltage and high-frequency techniques, magnetism, nuclear physics and mathematics, in so far as they enter into the theory and practice of the main subjects. In other words, a compendium of all the information that a specialized laboratory must have at its command, but which we ordinary folk carry around in our heads, in our day books and our card indexes, stored away in the journals, annual reviews and the American engineering handbooks on our shelves—and in the hands and heads of our glassblowers, mechanics and other assistants. Here you can find tabulated details of the 38 sorts of image converters and intensifiers, the 33 different types of ion source, the 68 nuclear reactors so far built for research purposes and the 38 for energy production; but also the most complete and compact treatment of the properties of electron lenses, and of the design, construction and operation of electron microscopes yet provided.

Only a German could have conceived of such a project, only a man of very wide knowledge and experience could have planned and carried it through, only a von Ardenne could have done so in the Soviet Union, brought the text away with him and had it published on such a sumptuous scale in Eastern Germany. "To achieve uniformity in presentation, the whole work was written by one hand only," he records, and goes on to regret that he has not entirely succeeded, owing to extraneous difficulties, in the task of providing a bird's-eye view of the state of electron and ion physics in the year 1956. As it stands, the work contains as good a survey of it as one will find anywhere. It is inevitable that the German literature should receive more attention than the foreign, but American and English work is widely quoted, up to the second half of 1955, with, however, some unaccountable omissions, such as the work of Haine and Einstein on electron gun properties. It also follows from its individual nature, that the work of the author receives the greatest attention, sometimes to the neglect of more recent or more thorough treatments. In a very detailed author index running to 100 pages, "von Ardenne" occupies 5½ pages. The inventors of the electron microscope, von Borries and

Ruska, who have been active over an equally long period, rate 1½ pages between them, and Zworykin, nearest comparable to von Ardenne in versatility, only ½ page. More seriously, it is often difficult to be sure how much of the author's work is purely paper project and how far it has been proved in the laboratory.

Be that as it may, here is a work of unique character and value—part International Critical Tables, part text-book, part record of ten years individual research, and part history of his subject in the wider sense. If the special nature of its origin and composition is borne in mind, everyone will find much of interest in it and something of value. As a source-book it has no equal in its particular field, the greatest overlap being with the American Institute of Physics "Handbook" (which lists only 38 reactors of all types, but has fuller information on particle accelerators), and with Fink's "Television Engineering Handbook" or Terman's "Radio Engineers' Handbook", both of which are very weak on electron lenses. Taken in conjunction with such other reference works, and here and there with a pinch of salt, it will prove a most valuable addition to the library of every laboratory of electron and ion physics.

V. E. COSSLETT

SEMICONDUCTOR PHYSICS

Fizika Poluprovodnikov

By A. F. Ioffe. Pp. 491. (Moscow and Leningrad: Publishing House of the U.S.S.R. Academy of Sciences, 1957.) 20 roubles.

THE author of this book has long been associated with the study of the physics of solids. Born in 1880, Dr. A. F. Ioffe became an academician in 1920 and has worked on X-rays and crystal physics in their many aspects. In 1942 he was awarded the Stalin Prize for his research in semiconductors and he is at present director of the Institute of Semiconductors of the U.S.S.R. Academy of Sciences.

The book is a revised and enlarged edition of "Semiconductors in Contemporary Physics" published in 1955. It is essentially descriptive in style and, generally speaking, detailed theoretical treatments are not presented, in order to avoid obscuring the physical argument by analytical complexities.

The introduction traces the history of semiconductors which in the early days were taken to be those materials the resistivity of which lay in the broad no-man's land between 10^{-5} and 10^{10} ohm/cm. Early observations of photoconductivity, rectification and the dependence of conductivity on temperature led to important technological applications long before there existed an adequate theoretical understanding of these processes. To-day the great importance of this field of physics is emphasized by Ioffe's list of sixteen distinct fields of technical application of semiconductors. Furthermore, understanding of the physical bases of the phenomena involved has greatly advanced in the last decade and in some cases may even be said to be complete.

The first three chapters are concerned with electrical conduction in solid electrolytes, metals and electronic semiconductors and provide the background for the later more detailed chapters. Chapter 4 deals with the basic quantum theory of semiconductors and gives a lucid outline of the band theory of crystals and of the factors determining the distribution and occupancy of electronic energy-levels.

Chapter 5 is by far the longest (occupying nearly half the book) and deals with physical phenomena in semiconductors. This commences with a discussion of lattice properties, defects, impurities and the thermal motion of the lattice and thence proceeds to the scattering and mobility of electrons. Consideration is then given to boundary-layer phenomena and p–n junctions, and their implications for rectification, transistor action and photo-voltaic effects are briefly described. In passing, Ioffe compares the capital cost of photo-electric and thermo-electric solar batteries for generating one kilowatt of electrical power and arrives at the respective figures of 400,000 and 1,000 dollars. Although the former figure should be divided by about 5 in view of the recent reduction of the cost of silicon cells, and operating factors have to be taken into account, this comparison is still strikingly significant. External electron effects (contact potential, photo-electric effect, emission and secondary emission) and the magnetic properties of semiconductors are reviewed in outline. The chapter then concludes with a section on thermal conductivity and one on thermo-electricity which is a condensation of the author's monograph (1955) on the subject. It provides a survey of the theory of the Seebeck and Peltier effects and an excellent discussion of the design of thermo-electric generators and refrigerators with estimates of attainable efficiencies.

Chapter 6 deals with the measurement of both the fundamental constants and the phenomenological parameters of semiconductors, though not in sufficient detail to enable the experimental procedures to be set up and for their difficulties and precautions to be fully appreciated. The last chapter describes various classes of semi-conducting materials and discusses their properties in relation to existing theory. Deficiencies in these theories and the need to extend our knowledge of amorphous and liquid semiconductors are briefly considered in the conclusion. An addendum dated January 1957 sums up the data about the band structures of germanium and silicon and the energy-levels associated with impurities and defects.

Two features of the book immediately strike a Western reader. The first is the tracing of the historical development of semiconductor physics with particular reference to Russian contributions in the field. Thus the theoretical work of Davydov, Frenkel, Landau, Pekar and Tamm and the experimental work of A. V. and A. F. Ioffe, Juze and Losev among others are mentioned frequently. On the other hand, the names of Mott, Schottky, Shockley and Wilson scarcely receive mention.

The second point is that there are no references to original papers in the text, apart from incomplete references to papers by Telkes and Justi on thermo-electric effects; this is a disadvantage for a reader who wishes to follow up in more detail a topic which may interest him. Instead, there is, at the end of the book, a list of some forty books and review papers—and among those listed under the heading "in the Russian language" are the familiar names of Mott and Gurney, Seitz, Shockley and Wilson, referring to translations of their works. Instead of an index there is a contents list with about 140 entries. The book

is well printed and has 155 figures. Only a few minor errors have been detected.

The book would probably be of greatest interest to the non-specialist physicist and to the chemist and metallurgist who wished to perceive the rapid advances of semiconductor physics and technology in the perspective of contemporary science. Some idea of the anticipated demand can be seen from the publication data which indicate a printing of twenty thousand copies.

R. E. Burgess

ECONOMICS OF ATOMIC ENERGY

Economics of Atomic Energy

By Mary Goldring. (The Atoms for Peace Series.) Pp. viii+179. (London: Butterworths Scientific Publications, 1957.) 15*s*.

IT may come as a surprise to many people to learn that one of the best places to site a nuclear power station is at Niagara Falls where all available water is now used for generating electricity. The nuclear power station could operate there on almost 100 per cent load factor, and be used for pumping water back up the Falls. The water could then meet the peak demand for electricity in Ontario Province by installation of further hydro-electrical equipment. A somewhat similar concept is in mind in the recent decision to site one of the new Central Electricity Authority nuclear power stations in North Wales.

If the general public feels disturbed at the possible despoliation of the countryside, however, they may perhaps find some comfort in reading the first chapter of this book by Miss Goldring. It gives a delightful account of how a large nuclear power station such as Calder Hall or a large plutonium-producing factory such as Windscale is a most novel and remarkable installation. Virtually nothing goes in through the factory gate after building has finished, nothing appears to come out; there may be chimneys but no smoke emerges. It is remarked even that birds can be seen sitting on the top of the chimneys at Windscale though anybody who has seen these chimneys may feel that some poetic licence has crept in. It is a fact, however, that virtually nothing is brought into a nuclear power station, and only at rare intervals is waste fuel taken out in a lorry. In theory, the factory could be almost automatic in operation. Pictures of recently ordered Central Electricity Authority nuclear power stations show most elegant structures; even chimneys have disappeared. Even grid lines taking electricity from the power station could be placed underground at some extra cost.

Miss Goldring describes in some detail the various atomic factories which exist in the United Kingdom and gives a basic account of atoms, and the problems of using radioactive materials. Following this she discusses, in a most interesting chapter, the scale of investment which a country needs in order to enter the nuclear energy industry on a sufficient scale. She remarks that the United States, Britain and France are all spending about 0·6 per cent of their national income on atomic energy and she points out also that the minimum capital needed to start a nuclear energy industry is about £100,000,000. Much of the expenditure has been for military purposes in the case of the United States, the U.S.S.R. and the United Kingdom, but the fact that this expenditure has been made has enabled these powers to build factories which can have a civilian as well as a military application. The investment is probably not much less even if the military application is foregone. She points out, in particular, that the smaller industrialized countries are likely to have some difficulty in entering the nuclear energy industry entirely on their own; though, for a small country, Sweden is making rapid strides in this field just as it has in the aircraft industry. Although the non-industrialized countries and the comparatively small countries are unlikely to be able to develop atomic power on their own, there is great national prestige attached to the subject of nuclear energy and most of them will form atomic energy commissions. In due course these will be able to discriminate between various reactor designs and advise power companies on the installation in their country of small nuclear power stations. These will have been purchased from highly industrialized countries with a large nuclear energy industry. Miss Goldring notes, however, that it will be much cheaper for a very long time to come to use diesel engines of comparatively low capital cost, except in those cases where fuel is extremely expensive because of high transport costs. This fact is beginning to become more generally appreciated even in those circles where two to three years ago nuclear power was looked on as something which would end all misery and poverty. It is important to remember that the capital needed to exploit electricity or other sources of power is far greater than the capital cost of the power plant itself.

The author comments on the need for atomic power and points out, as many others have done, that atomic energy is very badly needed in Britain and also Japan. In fact it is among the highly industrialized countries, except the United States and the U.S.S.R., where the need is really urgent. The United States has large and cheap sources of coal, oil and natural gas, and the U.S.S.R. has no overall fuel problem. In the extreme west of Russia, however, fuel supplies involve high transport costs and here it may possibly pay to develop nuclear power in the next ten to fifteen years.

The author has a chapter on the cost of atomic power and in general she tends to follow the views that have been expressed by the United Kingdom Atomic Energy Authority; though she does conclude this chapter with the remark, "this is a subject on which it is possible to have more than one opinion". She gives a critical discussion of the costs of natural and enriched fuels.

On the subject of nuclear power station exports Miss Goldring is once again extremely realistic. She recognizes that the actual business is not likely to be large in terms of numbers of large nuclear power stations. Most industrialized countries will tend to build either a complete power station under licence or manufacture most of the components themselves.

Finally, the author gives an excellent review of relations with industry in the field of nuclear power, though she avoids the difficult question of exactly what these relations should be.

This is an entertaining book, and a few technical errors do not affect the main arguments. For the general public as well as the specialist it is well worth reading since the author has studied and appreciated the intricacies of a very complex subject.

J. V. Dunworth

Science and Its Background

By Dr. H. D. Anthony. Third edition. Pp. ix+352. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 20*s*. net.

TWO former editions of Dr. Anthony's short history of science received favourable notice in *Nature* (175, 962; 1955 and 162, 354; 1948). The present edition, the third, appearing only three years after the second, testifies in itself to the popularity of the work.

The author, a former grammar school headmaster, colonel in the Royal Army Educational Corps and university extra-mural lecturer, has a wide knowledge of the requirements of the earnest student of the history of science in relation to social needs.

In the third edition of the book most of the chapters deal with the work of individual men of science selected not merely as a part of scientific history but also because of the value of their work to-day. Nevertheless, the historical background is that not only of isolated biography but also of the continuous history of human affairs. Even in so comparatively short and straightforward a work the temptation to turn a short history of science into the achievements of a hundred great men has been avoided. In this connexion the various time-charts will be invaluable.

The present edition of the book includes a chapter on the International Geophysical Year (which appeared before the Russian Earth satellites) and two new chapters on the post-war utilization of science and the pursuit of science for its own sake.

The book is an admirable short introduction to the history of science for the sixth-form pupil and the intelligent layman. The social importance of such a book increases every year. W. L. SUMNER

Britain's Nature Reserves

By E. M. Nicholson. Pp. 175+65 plates. (London: Country Life, Ltd., 1957.) 30*s*. net.

THE Director-General of the Nature Conservancy has written this book to explain the objects and scope of the Nature reserves, and especially the functions of the Nature Conservancy itself. The greater part of the book consists of concise descriptions of the more important reserves, indicating the reasons why they are of interest and, sometimes, the character of the work in progress and the way the reserve contributes to the larger scheme. The location of the reserves is clearly indicated and the book is illustrated by numerous well-chosen photographs which further indicate the nature of the work and may well help to enlist co-operation and goodwill as well as the understanding which Mr. Nicholson seeks to promote. The book is not limited to the Conservancy's own reserves, but includes some of the important local reserves and also some of those of other bodies such as Wicken Fen, of the National Trust, Skokholm, of the West Wales Field Society and Field Studies Council, and Minsmere Level, of the Royal Society for the Protection of Birds.

The core of the book, however, is in the introduction. In those twenty pages Mr. Nicholson gives an account that could scarcely be bettered of the Nature reserve movement in Britain, the tasks that confront it and the way it is setting about those tasks. He explains clearly just why it is necessary for access to some reserves to be restricted and the ways in which Nature lovers can help the work, as well as some of the implications of its work for Britain's economy and for the advancement of science. This is a book that was needed, but Mr. Nicholson's introduction deserves to be issued as a reprint at a price which would place it in the hands of thousands whom a 30*s*. book is unlikely to reach.

Art and Analysis

An Essay toward a Theory in Aesthetics. By Prof. Edward G. Ballard. Pp. xv+219. (The Hague: Martinus Nijhoff; London: B. T. Batsford, Ltd., 1957.) 30*s*. 6*d*.

IN this book, Prof. Ballard has performed a valuable duty in discussing the place which æsthetics should occupy in the broad hierarchy of knowledge. Many people have attempted this before; what distinguishes the present work is its emphasis upon the historical development of the subject, and how the persistent effort to 'locate' the beautiful has stimulated contemporary interest. There is no doubt that much æsthetic theory shares a common boundary with philosophy, especially that part of it which embraces experience, as in the work of Whitehead.

But however elusive an æsthetic object seems to any particular generation of thinkers, we come back to the presence of symmetry as an essential, not sufficient in itself (by traditional standards), but coercive. To Plotinus this extra something was a 'shining through', but the concept gained strength centuries later in the *claritas* of St. Thomas Aquinas and other scholastics. This factor is closely related to form, as if to suggest that inanimate shape could achieve sublimation (under the appropriate conditions) in a way not wholly different from human advancement. It is this element of the sublime which sensitive mathematicians have felt in their preference for one approach to a problem rather than another. In brief, Prof. Ballard's theme is analytic rather than synthetic, though he manages to hold a delicate balance with æsthetics nicely poised between metaphysics and criticism.

F. I. G. RAWLINS

Studies on Fertility

Including papers read at the Conference of the Society for the Study of Fertility, Birmingham, 1955. Edited by Prof. R. G. Harrison. (Vol. 7 of the Proceedings of the Society.) Pp. ix+156+28 plates. (Oxford: Blackwell Scientific Publications, 1955.) 25*s*. net.

"STUDIES on Fertility, 1955" is Vol. 7 of the Proceedings of the Society for the Study of Fertility. It contains certain papers selected from those read at the Birmingham conference of the Society in 1955 (see *Nature*, 176, 340; 1955), and a number that report original work. Part 1 deals with the male and includes a lucid account by Clare Harvey of the cytology of abnormal spermatogenesis in subfertile men, and three useful papers, by members of the Department of Anatomy of the University of Liverpool, on testicular physiology in the rat and guinea pig. Among them is a study by R. Harris and R. G. Harrison of the damaging effects of cold on the seminiferous epithelium of the guinea pig. In other papers, Marcus W. H. Bishop discusses the inter-relationship of semen characteristics in seventy-six bulls of seven breeds, and T. D. Glover the effects of scrotal insulation on the semen of rams. Three clinical papers introduce the section of the book dealing with the female, to which A. M. Dalcq, of Brussels, contributes a valuable summary of the

information provided by cytochemical techniques about processes of synthesis in the egg of the rat and mouse. The final three chapters deal with the œstrous cycle of the cat; the occurrence of supernumerary spermatozoa in the fertilized ova of rabbits; and fertility in the ewe—all of them accounts of valuable and interesting work.

Twentieth-Century Bestiary

(A *Scientific American* Book.) Pp. xi+240. (London: G. Bell and Sons, Ltd., 1957.) 13*s*. 6*d*. net.

WITH 130,000 regular subscribers and many casual sales from news-vendors *Scientific American* has now become one of the most powerful agents for spreading scientific knowledge throughout the United States. So popular have been its non-technical articles that, two years ago, the Board of Editors launched a series of short books on specific areas of science consisting of contemporary articles from the journal. These books have been as successful as the journal and are now being published for British readers. Each is designed to elucidate the new knowledge recently gained by research in a particular field of science and to acquaint the reader with the problems which are at present being investigated.

As its name implies, "Twentieth-Century Bestiary" is concerned with certain aspects of zoological science. These, presumably, have been chosen because of the appeal of the original articles and represent but a small sample of current zoological investigations. The random sample includes two articles on the balance of Nature, three on mating, two on the social insects, two on the origin of species, three on what is aptly called physiological engineering, four on bird flight, one on sonar in bats and others on laboratory entomology and researches on primates. The authors include American, British, Danish and Swiss investigators who are as well known for their abilities to write as for the quality of their researches. Between them they have produced a book the contents of which belie the quaintly chosen title. This is no moralizing treatise but an unvarnished account of how the frontiers of science are being extended by imagination, patience and humility.

The Great Chain of Life

By Joseph Wood Krutch. Pp. xiv+227. (London: Eyre and Spottiswoode, Ltd., 1957.) 21*s*. net.

IN this little introduction to biology a distinguished American naturalist challenges many accepted beliefs. He questions, for example, whether the complexity of a microscopic, one-celled animal can be explained by natural selection or any other logical theory. He believes that joy and other emotions are not confined to man and that animals—even in zoos—develop an awareness of, and an interest in, people of which we would never believe them capable if we knew them only in the wild. . . . "Monkeys are notorious exhibitionists and gibbons, especially, will put on performances at intervals after a preliminary ballyhoo of howls to collect an audience." In his love for, and zeal to promote the study of, animals as individuals, Krutch also argues that laboratory biology, which has tended to become the most earnestly cultivated kind of scientific study, is precisely the kind least likely "to stimulate compassion, love or reverence for the creatures it studies . . . the laboratory scientist is not of necessity drawn into any emotional relationship with animals or plants and the experiments which must be performed are more likely to make him more, rather than less callous, than the ordinary man".

Does Krutch really believe this? Could he produce evidence? Do most biologists believe in a mechanized process of natural selection which is making the animal machine more and more efficient? That man is merely an extrapolated version of the Anthropoidea? That most biologists do not accept that there are varying degrees of 'intelligence' and 'emotion' in all animals? Krutch has written a book which will appeal to many—and especially those who find delight in erecting their own Aunt Sallies to aim at. It is a masterpiece of unsubstantiated assertion.

T. H. HAWKINS

The American Arbacia and Other Sea Urchins

By Ethel Browne Harvey. Pp. iv+298+16 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1956.) 48*s*. net.

THIS is the story of an egg, or, to be more precise, an annotated bibliography and summary of the story of an egg. The first sixty pages are devoted to a description of the etymology, history and natural history of sea urchins (still called sea eggs in parts of Britain) in general and *Arbacia punctulata* in particular. The next eighty pages review investigations into the normal and modified development of the egg of *Arbacia*. This is followed by eighty pages of a "compilation of experimental work" arranged alphabetically and set down in note form. The bibliography lists 1,500 titles and is stated to include all the important papers written on *Arbacia* between 1850 and 1954. The index is admirable. The scholarship involved in this work is immense, and the book is a most complete guide to the voluminous literature which has grown up on sea urchin eggs. These eggs are one of the most investigated of biological entities, rivalling even *Drosophila* in popularity.

The extent of the investigations on the American species can be gauged by the numbers used at Woods Hole and the decline in population which appears to have been brought about chiefly by overcollecting. In the summer of 1933, 70,000 were collected. In 1949, although the same number were ordered, only 4,000 could be found. The chief value of this book lies in its use as a reference source, for which it is indeed indispensable. The first half may be used also by students and teachers as an account of the embryological and cytological investigations, but it is rather concentrated.

D. B. CARLISLE

Marine Algae of the Northeastern Coast of North America

By Prof. William Randolph Taylor. Second revised edition. Pp. ix+509. (Ann Arbor, Michigan: University of Michigan Press, 1957.) 12.50 dollars.

THE new and revised edition of this important work is especially welcome because of the advances in knowledge of the life-histories and taxonomy of the algæ which have accrued in the past twenty years. The area with which the book deals extends from the coast of Virginia to the Arctic Circle and contains, therefore, elements of the northern flora with subarctic tendencies as well as plants which inhabit warmer waters. The volume, in consequence, will be welcomed by algologists from many locations either for direct or comparative reference. On this account one regrets that, in the new edition, biblio-

graphical references to plants occurring in areas outside North America have been omitted, though admittedly they are now available in other standard works. The information that such references contain has, of course, been incorporated where it affects classification and nomenclature, though the author has exercised commendable caution where facts remain so far unconfirmed. The volume is beautifully produced and the excellent plates, mostly by Dr. Chin-Chih Jao, have been reproduced with some modification to the captions. Prof. Taylor is to be congratulated on the material and presentation of this new edition, which makes his extensive and detailed knowledge of the algæ of the area available to workers throughout the world. I would like to suggest that when he gives us a third edition, a map might be included either on the end-papers or as a frontispiece.

LILY NEWTON

Physical Chemistry for Students of Pharmacy and Biology

By Dr. S. C. Wallwork. Pp. xi+307. (London and New York: Longmans, Green and Co., Ltd., 1956.) 25*s*. net.

IN his selection of those portions of physical chemistry which are particularly the concern of the biological sciences, the author states that he follows the recommendations, and covers the syllabus, of the Pharmaceutical Society of Great Britain, and that he fulfils the requirements of students of pharmacy and biology taking recognized courses in these subjects in technical colleges and universities. The book's eleven chapters deal with: mathematical preparation, the properties and constitution of matter, the structure of atoms, the structure of molecules, chemical reaction, properties of solutions, electrolytic dissociation, electrochemical cells, acids and bases, surface chemistry, and colloids. The book has a bibliography, a table of logarithms, and sets of problems. Dispersed through the text are ten representative instructional experiments with the requisite practical directions. Dr. Wallwork's explanations, clear, well expressed, and given from the point of view of the modern electronic theory, should conduce to an understanding of the subject. He uses mathematics—but not beyond simple calculus—when by doing so he attains the best presentation of the subject in question; and in Chapter 1 he revises and expounds the elements of the mathematics required.

G. FOWLES

The Reactive Intermediates of Organic Chemistry

By John E. Leffler. Pp. x+275. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 6 dollars.

"THE objectives of the present book are to provide some of the background of information about stable radicals and ions needed by those interested in organic reaction mechanisms, to point out some of the pitfalls awaiting the unwary, and to show some of the criteria for preferring one type of intermediate over another." These aims, set out by the author in his preface, have been fully achieved, and the result is a book which can be recommended to undergraduate and postgraduate students and working research chemists as presenting an accurate, stimulating and eminently readable account of the role of radicals and ions in organic reactions in solution.

The first chapter begins with a section on the physical properties of free radicals leading to a summary of the preparation, stability and reactions of the triarylmethyl and some analogous radicals. Chapter 2 gives an account of the formation and behaviour of unstable carbon radicals. Biradicals are described in Chapter 3, while Chapter 4 gives an excellent account of the heteroradicals, those radicals in which the unpaired electron is associated with an atom other than carbon. The treatment of free radicals throughout is very good.

The next three chapters are devoted to carbonium ions, being divided according to their formation by reversible or irreversible dissociation or by addition reactions. These are followed by an interesting chapter on analogues of carbonium ions, the common feature being the possession of low-energy orbitals in excess of the electrons available to fill them. Chapters 9 and 10 describe the formation and reactions of carbanions. An account of base-catalysed reactions in Chapter 11 is followed in Chapter 12 by a most useful comparison of radical and polar reactions.

The book is well produced and there are very few misprints. The apt quotations from Mark Twain and other authors are a delight in themselves.

H. S. TURNER

Optics

By Prof. Bruno Rossi. (Principles of Physics Series.) Pp. xii+510. (Reading, Mass.: Addison-Wesley Publishing Company, Inc., 1957.) 8.50 dollars.

THIS is a text-book for university honours and pass degree students. The main emphasis is on the wave theory of light including the electromagnetic theory, and this subject is treated up to the standard of an honours physics degree in Great Britain. Other aspects of optics are briefly reviewed. The optics of lenses and of instruments occupies forty pages, but a good deal of this is used in an exposition of elementary lens theory which would be included in a school course in Britain. Quantum phenomena are discussed in fifteen pages and realtivistic optics is just mentioned. The account of wave-theory is theoretical: there is very little description of experimental methods.

Some parts of the book appear to be written for readers who are intelligent and possessed of the mathematical knowledge and ability normally possessed by students who reach the final year of an honours physics course. These parts are incisive, clear and interesting. Not only students but also many lecturers could derive benefit from them. In other parts of the book, and particularly in the earlier chapters, the author attempts to expound difficult mathematical concepts to students with a weak mathematical background. These sections appear to be much less successful.

The author has provided a large number of examples from which a teacher could select those appropriate to his own students.

Relaxation Spectrometry

By Prof. E. G. Richardson. Pp. viii+140. (Series in Physics.) (Amsterdam: North-Holland Publishing Company.) 20 guilders. 40*s*.

THE present book is essentially an exposition of modern experimental methods available for studying stress relaxation in solids, liquids and gases.

The reader is first introduced to the representation of visco-elasticity by means of models of the spring-and-dashpot type, to the equations of such rheological models and their canonical forms, and to their utilization in analysing relaxation in static and dynamic stress fields. The main part of the book is devoted to: subsonic relaxation as typified, for example, by the damping of oscillations of a torsion pendulum; methods of measurement applicable at sonic frequencies, for example, the vibrating reed; and spectrometry in the ultrasonic range. A short account of dielectric relaxation is also given, and the analysis of complex spectra by the linear superposition of relaxation-times, as well as the thermodynamic implications of the spectra, are briefly discussed.

It is clear from the book that, while experimental methods for measuring relaxation spectra are comparatively well advanced, little is as yet known of the significance of the spectra, particularly in solids. Some modern techniques, such as the introduction of a 'blue-shift' into the relaxation spectra by neutron bombardment and, on the theoretical plane, the mathematics of stochastic processes may, however, soon fill some of the major gaps in the science.

Irrespective of the actual pattern of future development, a sound knowledge of what has already been achieved will remain the research worker's indispensable prerequisite for successful work. Prof. Richardson's book provides this information. It is sure to be well received by all concerned with this branch of physics.

P. Feltham

An Introduction to the Cathode Ray Oscilloscope

By Harley Carter. (Popular Series.) Pp. viii+100. (Eindhoven: N.V. Philips' Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1957.) 12*s.* 6*d.*

THIS little book explains the general principle of the oscilloscope, and the associated time-base, amplifier, and power-supply circuits. So far as the 'popular' aspect of the book goes, it is written simply and without any mathematical theory, and it should be quite useful to the kind of reader who wants to know merely how oscilloscopes work, and why people use them. But Mr. Carter goes a good deal further than this, and is really writing for the beginner who is prepared to work his way solidly through the book and to go so far as making up various circuits for himself in order to see how they work. He discusses the characteristics of the various standard types of tube, and gives detailed instructions for the assembly of four complete oscilloscope circuits; at least two of these are simple enough to appeal to relatively inexperienced hands. The book is handsomely produced and finished, and while it does seem rather expensive for its size it is not extravagantly so. Indeed, experimenters who are thinking of building an oscilloscope will probably find it very good value.

Probability

An Intermediate Text-book. By M. T. L. Bizley. Pp. viii+230. (Cambridge: At the University Press, 1957. Published for the Institute of Actuaries and the Faculty of Actuaries.) 20*s.* net.

THIS book, designed to meet the requirements of actuarial students, is concerned solely with classical probability theory, although the importance of relating this to statistics is emphasized. The development is elementary, but sound within the limits of an acknowledged incompleteness of discussion of the fundamental nature of probability. The general account of alternative definitions of probability is indeed good, and the subsequent presentation of standard theory of combinations of probabilities is excellent. The solution of certain types of problem by difference equations is well illustrated, and the reader is introduced to the theory of runs and other Markov chains. The final chapter, on continuous variates, is less satisfying, in that it scarcely goes beyond somewhat unexciting geometrical problems. The book, despite the aridity that is perhaps inseparable from its subject, can be recommended to a student skilled in algebraic manipulation, or to a teacher in search of a modern text with a good systematic plan and an abundance of examples. It is unfortunate that so many of the examples, good though they are as exercises in probability calculus, are either explicitly based on random drawings from bags and urns or have the irritating pseudo-realism of relating to people who form random committees and keep large numbers of indistinguishable pairs of gloves in a drawer; more use might have been made of actuarial problems and of applications of probability theory to science and industry.

D. J. Finney

Tables of Integrals and Other Mathematical Data

By Prof. Herbert Bristol Dwight. Third edition. Pp. x+288. (New York and London: The Macmillan Company, 1957.) 21*s.* net.

THE fact that a third edition of this collection of formulæ and tables has been called for is an indication of its usefulness. The first 193 pages consist of lists of formulæ, including those of derivatives and integrals, relating to the elementary functions, elliptic and Bessel functions, and surface zonal harmonics (Legendre polynomials). The next two sections consist of a ten-page list of definite integrals and a five-page set of notes on ordinary differential equations. The last 75 pages contain tables of numerical values of elementary functions, complete elliptic integrals, the probability integral and the Kelvin functions *ber*, *bei*, *ker*, *kei*, in the tabulation of which the author was a pioneer.

For engineers, physicists and practical mathematicians this is an excellent reference book, very well classified. The first sentence of the preface to the first edition is a glimpse of the obvious: "The first study of any portion of mathematics should not be done from a synopsis of compact results, such as this collection". The objection which some teachers have to the existence of such collections seems to result from a misunderstanding of their purpose. After all, it is largely because practical use is made of such formulæ that much mathematics is taught, and no one can be expected to remember them all, or work them out every time they are wanted.

In the third edition there are a few unimportant additions to the formulæ, and useful tables of sines, cosines, tangents and cotangents of angles in degrees and hundredths have been added. It is a pity that the opportunity was not taken to bring the table of references up to date. The most recent reference is dated 1947–48, and many relevant tables have been published since then.

The printing and binding are very good.

G. A. Garreau

(*Continued from p.* 1254)

A potential difference, applied between two electrodes on the diamond, produces luminescence over a wide range of potential values. Due to the high refractive index the whole diamond appears to luminesce, with a band of wave-lengths in the 5400-A. region, but closer microscopic inspection shows that the luminescence is in fact confined to small spots on the diamond. There may be a dozen of these which are not necessarily in the immediate neighbourhood of the electrodes and seem to be independent of the precise form of the potential probe, but are sensitive to its position. If the graphite layer is scratched off in the vicinity of one of these luminescent centres, the effect is destroyed for that particular one.

The intensity increases with an increase in the applied voltage, and in one particular case could be observed from 30 volts to 1,500 volts. Changing the polarity of the electrodes makes no difference to the locality, colour or intensity of the spots. They are equally unaffected by a temperature variation from that of liquid air to 300° C.; by immersion in oil, or a sprayed plastic sheath; or by ultra-violet or infra-red irradiation.

None of these diamonds exhibits counting properties; only one of them shows fluorescence under ultra-violet irradiation, but all of them show blue luminescence when bombarded by electrons.

Unlike some of the effects reported by Wolfe and Woods[1] the diamonds return to their normal state when the surface is cleaned and display no luminescence. Neither quartz nor glass was found to display luminescence after similar treatment.

The investigation is far from complete; but this communication is prompted by a recent observation of Fischer[2] that when the dielectric properties of the diamond have been broken down by sufficiently high currents and fields, a green luminescence is observed. The breakdown process may produce graphitization of parts of the diamond and the effect may be of the same nature as that reported here.

This research has been supported financially by Industrial Distributors (1946), Ltd., to which we are indebted.

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[1] Wolfe, R., and Woods, J., *Phys. Rev.*, **105**, 921 (1957).
[2] Fischer, A., *Z. Phys.*, **149**, 107 (1957).

Ranque Vortex-Tube Combustion Chamber

Recent experiments carried out here lead to the conclusion that the vortex tube of Georges Ranque[1] may form an extremely useful compact combustion chamber and also a possible research tool for the investigation of cool flames. Many applications of the vortex tube have appeared during the past fifteen years, as shown by Westley[2], but, so far as it has been possible to ascertain, the nearest approach to the burner described here is due to Moore and Martin[3] and Martin (private communication). Moore and Martin, using a single-outlet vortex tube made of 'Pyrex' glass, discovered the peculiar behaviour of premixed propane-air flames in this burner, together with the extreme flame stability obtained over a wide range of ratios of air to fuel. Owing to the limitations of their air supply, and to the size of the glass tube, they were apparently unable to obtain the rates of flow needed for some of the behaviour described here.

The burner used in this Department consists of a standard vortex tube of the type described by Ranque, with a range of orifices to restrict the flow in one direction. The main tube has an inside diameter of one inch, and was fed by a tangential nozzle, of rectangular cross-section, 0·017 in. × 2·30 in. Orifices of diameter $\frac{5}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{8}$ in. and $\frac{1}{4}$ in. are available, and the burner is also run with both ends open, and with the orifice end closed off, when it resembles that of Martin and Moore. Due to the high temperatures involved, the complete burner is made of steel.

With both ends open, and with all the orifices, the striking-back phenomenon of Moore and Martin is encountered, but it is found to be even more stable when there is a double exit from the tube than under the conditions which they used. When the ratio of air to fuel is increased, however, two further forms of combustion are found to exist. The first, a detonating or howling combustion with a very high heat release occurs at the lower ratios of air to fuel, while the second, a quiet mode of combustion with relatively small heat release and very steep temperature gradients across the flame-front occurs at the higher ratios of air to fuel. The latter flame also produces large quantities of formaldehyde, acetaldehyde and propionaldehyde.

The upper and lower limits of these forms of combustion have been established, the upper limit of the aldehyde-producing flame being complete extinction. It is apparent that the function of the orifice is to allow the induction of a large quantity of air into the system, since the change from one form of combustion to another occurs at lower ratios of air to fuel for the premixed gases as the orifice size is increased. The change from one mode to the next is also affected to a very great extent by the temperature of the tube; as tube temperature increases, so the ratio of air to fuel at which any flame occurs also increases (Fig. 1).

The various aldehydes in the flame were detected by means of the semicarbazide–hydrochloride reaction,

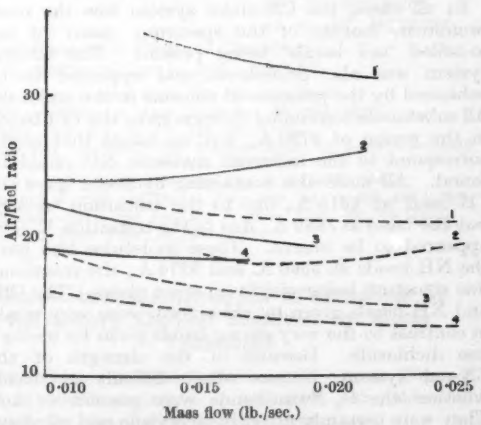

Fig. 1. Sample performance curves: (1) Extinction, tube temperature 1,100° F.; (2) extinction, tube temperature 500° F.; (3) detonation to aldehyde-producing flame, tube temperature 1,100° F.; (4) detonation to aldehyde-producing flame, tube temperature 500° F. Orifice end closed, ———; $\frac{1}{4}$ in. orifice, – – – –

together with a determination of the melting points for the resulting semicarbazones. Current spectrographic work further confirms these results. The work is continuing; it is hoped to publish more information on this combustion chamber.

J. M. F. Vickers

Mechanical Engineering Department,
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Lincoln 8, Nebraska. Aug. 5.

[1] Ranque, G. J., *J. Phys. et Rad.*, **4**, 324 (1933).
[2] Westley, R., "A Bibliography of the Vortex Tube", College of Aeronautics, Cranfield, Note No. 9 (1954).
[3] Moore, N. P. W., and Martin, D. G., *Fuel*, **32**, 393 (1953).

Spectra of Flames supported by Active Nitrogen

When organic substances are introduced into a stream of active nitrogen, a luminous reaction zone is observed, closely resembling the atomic flames given by hydrogen and oxygen. The spectra of these luminous reaction zones have been photographed on 'Ilford Zenith' plates, using a 'Hilger' medium quartz spectrometer and exposure times of 4–6 hr.

Cylinder nitrogen with less than 0·05 per cent of oxygen was activated in a high-frequency electrodeless discharge. Flow rates of 10–15 cm.³/sec. were used, and the pressure in the apparatus was usually 2–4 mm. of mercury. The organic reactants were introduced into the active nitrogen at a point about 4 cm. beyond the discharge tube, and the luminous zone was viewed through a silica window attached to the end of the reaction tube.

The size and shape of the zone depended largely on the flow rate of the organic reactant. In the present work, the flow rate was adjusted so that the luminous zone was localized on the nitrogen inlet tube, which corresponded to a flow rate of about 0·5 cm.³/sec. in the case of acetylene. The reaction tube had to be cleaned periodically since most substances used formed a polymer on the walls of the tube.

The spectra of flames produced by the following substances were photographed:

C_2H_2, C_2H_4, *cis*-CHCl=CHCl, CHCl=CCl_2, CCl_2=CCl_2, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4, C_2H_5Cl; C_2D_2

In all cases, the CN-violet system was the most prominent feature of the spectrum, many of the so-called 'tail bands' being present. The CN-red system was also prominent, and appeared to be enhanced by the presence of chlorine in the molecule. All substances containing chlorine gave the CCl-bands in the region of 2790 A., but no bands that might correspond to the unknown molecule NCl could be found. All molecules containing hydrogen gave the CH-band at 4315 A., due to the transition $^2\Delta \rightarrow {}^2\pi$; but the band at 3889 A., due to the transition $^2\Sigma \rightarrow {}^2\pi$, appeared to be absent. These molecules also gave the NH-heads at 3360 A. and 3370 A., the rotational fine structure being visible on some plates. The CH- and NH-bands given by chloroform were very weak, in contrast to the very strong bands given by methylene dichloride. Because of the strength of the CN-red system, it was often difficult to decide whether the C_2 Swan-bands were present or not. They were certainly given by acetylene and ethylene, but were not given by carbon tetrachloride. The nitrous oxide β- and γ-systems were occasionally present faintly, especially in the case of carbon tetrachloride and tetrachlorethylene.

In addition to the above bands, a complex group of heads was observed in the region of 3290 A., degraded to the violet, with all molecules except carbon tetrachloride and tetrachlorethylene, and possibly chloroform. The intensity of these bands correlates quite well with the intensity of the CH- and NH-bands, and because of this and their complex structure, it was thought that the bands were due to hydrogen cyanide, which is known to be the main product in the reaction of hydrocarbons with active nitrogen[1]. Consequently, deuteroacetylene (C_2D_2) was prepared by the action of heavy water on purified calcium carbide, giving a product of 97·5 per cent purity, and the spectrum of the flame produced by passing this into active nitrogen was photographed. The spectrum of an iron hollow-cathode lamp was used as a comparison spectrum. A comparison of this plate with one given by methylene dichloride showed that the structure of the unknown bands was identical, and that the expected isotopic shift was less than 4 cm.$^{-1}$. It therefore seems unlikely that the bands can be attributed to an emitter containing hydrogen, such as hydrogen cyanide.

The fact that the bands are given only by molecules which contain hydrogen may be due to some kinetic requirement, but the bands are not given when molecular hydrogen and carbon tetrachloride are introduced into active nitrogen. It is hoped that further work now in progress will help to clarify the problem.

This work was carried out as part of Contract *AF* 61(514)–1117 with the A.R.D.C. of the United States Air Force. We thank H. W. Thompson for the loan of a spectrograph.

K. R. Jennings
J. W. Linnett

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Oxford. July 30.

[1] Evans, H. G. V., Freeman, G. R., and Winkler, C. A., *Can. J. Chem.*, **34**, 1271 (1956).

Production of Vibrationally Excited Oxygen Molecules in the Flash Photolysis of Ozone

Previous work on the photolysis of ozone has led to the conclusion that a simple atom-chain mechanism is incapable of explaining the experimental facts. The existence of an energy chain involving excited oxygen molecules has gained wide acceptance due to the work of Schumacher[1], Heidt and Forbes[2], and Ritchie[3]. The nature of the excitation involved in the energy chain was not known, however, most workers assuming it to be the $^1\Sigma_g^+$ state of the oxygen[4]. Experiments on the flash photolysis of ozone[5] have enabled us to show that the excitation is purely vibrational, the oxygen being formed in the ground electronic state with up to 16 quanta of vibrational energy, by reaction (1) which is exothermic to the extent of 93 kcal./mole for $O(^3P)$ and 138 kcal./mole for $O(^1D)$.

$$O + O_3 \rightarrow O^*_2 + O_2 \qquad (1)$$

After allowing for the observed vibrational excitation and considering that spin conservation will be effective, the second oxygen molecule should be produced in the $^1\Delta g$ state according to

$$O(^3P) + O_3(^1A) \rightarrow O_2^*(^3\Sigma_g^-) + O_2(^1\Delta g) \qquad (2)$$

which would reduce the amount of energy available

Table 1. SCHUMANN–RUNGE BAND ORIGINS*

This work (absorption) (A.) (in air)	Previous work† (emission) (A.) (in air)	Calculated (A.) (in air)	v'	v''	Intensity (visual estimate)
3039·5		3039·3	1	12	2
3097·5		3097·3	2	13	3
3104·3	3104·3	3104·2	0	12	7
3157·6		3157·7	3	14	3
3162·8		3162·5	1	13	4
3223·0		3223·0	2	14	6
3232·9	3232·9	3232·9	0	13	10
3357·0	3356·8	3356·8	2	15	5
3370·1	3370·1	3370·1	0	14	9
3500·0	3500·0	3499·3	2	16	3
3516·6	3516·6	3516·6	0	15	8
3583·0	3583·0	3582·7	1	16	1
3673·2	3673·2	3673·0	0	16	2

* The bands are so strongly degraded that the head is only about 0·5 A. removed from the origin.
† Taken from Pearse and Gaydon, "The Identification of Molecular Spectra" (Chapman and Hall, London, 1950).

for vibrational excitation of the $O_2^*(^3\Sigma_g^-)$ from 93 to 72 kcal./mole.

The vibrational energy distribution of the oxygen molecules has an apparent maximum at $v''=14$ (56·2 kcal./mole) and falls off sharply at $v''=12$ and 16 (49·0 and 63·2 kcal./mole). Table 1 gives the details of the observed spectrum of the vibrationally excited oxygen molecule O^*_2. None of these bands has previously been observed in absorption, although most of them have been seen in emission.

In the photolytic decomposition of ozone the primary step might lead to the formation of $O_2(^3\Sigma_g^-)+O(^3P)$, $O_2(^1\Delta g)+O(^1D)$ or $O_2(^1\Sigma_g^+)+O(^1D)$. Formation of the vibrationally excited oxygen in this step is unlikely from various aspects such as the small change in bond-length going from ozone to oxygen. The most conclusive evidence that the vibrationally excited oxygen, O^*_2, results from the secondary reaction (1) is obtained from a study of the reactions given in Table 2. From this we can see that, in an exothermic reaction involving the attack on a triatomic molecule by an atom, the new bond formed has an initial vibrational energy greatly in excess of normal.

Recently, Benson[8] has claimed that the thermal decomposition of ozone can be explained without the necessity of an energy chain. His suggestion that the excited oxygen molecules produced in reaction (1) can dissipate their energy more rapidly than they can transfer it to ozone would be reasonable if the excitation were electronic. We have shown, however, that it is vibrational and that the excess energy can be retained through many collisions, for in a mixture of ratio nitrogen/ozone = 40/1 it was possible for us to detect absorption due to vibrationally excited oxygen molecules, O^*_2, up to 200 μsec. after flashing. It is to be noted that oxygen is a homopolar molecule and that loss of vibrational energy by radiation must be extremely slow, since it is limited to magnetic dipole or quadrupole radiation. Moreover, further analysis of our results indicates that the vibrationally excited oxygen is degraded by ozone more rapidly than by any other deactivating process. This can be due to physical deactivation and by decomposition of ozone, since the excited oxygen has sufficient energy to bring about the decomposition to ground-state molecules and atoms according to:

$$O^*_2+O_3\rightarrow 2O_2(^3\Sigma_g^-)+O(^3P) \qquad (3)$$

Taking account of the maximum vibrational energy observed, it is of course energetically possible that one $^1\Delta g$ or $^1\Sigma_g^+$ oxygen molecule is produced, but consideration of spin conservation makes this unlikely.

In view, therefore, of the results reported here, the evidence favouring the energy chain decomposition of ozone by vibrationally excited oxygen molecules would seem to be very strong, and the photon-propagated chain postulated by Benson for the short wave-length photolysis of ozone, if it occurs at all, should be negligible in comparison. This conclusion is further substantiated by the following considerations. Thus the reaction:

$$O(^1D)+O_3\rightarrow O_2(^3\Sigma_g^-)+O_2(^3\Sigma_u^-) \qquad (4)$$

suggested by Benson is about 4 kcal./mole endothermic whereas the reaction involving the formation of two $O_2(^3\Sigma_g^-)$ is highly exothermic, and in view of the analogous reactions shown in Table 2 vibrational rather than electronic excitation is indicated. We would also think that the photon-propagated chain would be inefficient, since the chain-length would be seriously decreased by the considerable escape of radiation which must occur, particularly in a vessel the walls of which have low reflectivity.

In further discussions of these points with Dr. B. A. Thrush, he has pointed out that the radiation emitted by the $O_2(^3\Sigma_u^-)$ formed in reaction (4), going to the ground-state $^3\Sigma_g^-$, would not be in the region of 2000 A. suggested by Benson. As stated previously, reaction (4) is endothermic and is unlikely to yield vibrationally excited molecules. According to the Franck–Condon principle, oxygen molecules in the lowest vibrational levels of the $^3\Sigma_u^-$ state will radiate to give molecules with high values of v'', and the bulk of the radiation will lie above 3000 A., where a photon chain can be excluded by the extreme weakness of the ozone absorption.

Table 2

Reaction	ΔH kcal./mole	Excited species	Highest vibrational level observed
$O+O_3$[1]	93 $O(^3P)$ 138 $O(^1D)$	O^*_2	$v''=16$ (63 kcal./mole)
$O+ClO_2$[2]	61	O^*_2	$v''=8$ (34 kcal./mole)
$O+NO_2$[3]	46	O^*_2	$v''=8$ (34 kcal./mole)
$H+O_3$[4]	80	OH^*	$v''=9$ (75 kcal./mole)

The excited species are in the electronic ground state in these reactions.

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Quantitative Estimation of Graphite in Refractory Carbon Deposits by X-ray Technique

THIS communication presents two curves (Figs. 1 and 2) which permit a quantitative estimation of graphite by use of an X-ray spectrometer.

The identification of graphite in carbon deposits produced by carbon monoxide attack of refractories by X-ray methods was first mentioned by Rowden[1]; later by Patrick and Sosman[2] and by Davis and

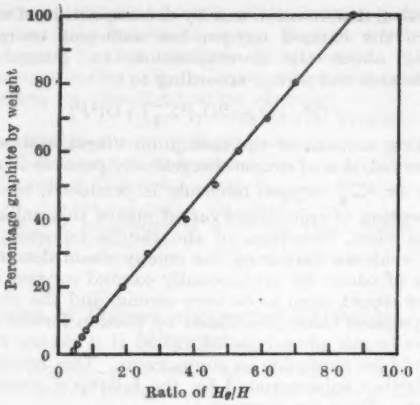

Fig. 1

Rigby[3]. To the best of our knowledge, no quantitative estimation of graphite in such deposits has previously been published. The very recent paper of Davis and his co-workers[4] has prompted submission of these results.

For the preparation of the curves, Dixon's 'Micro-Fyne' graphite was used with Baker's 'Analyzed' fluorite as the internal standard, as in the method outlined by Klug and Alexander[5]. The third component was magnetite. The three materials were reduced to minus-325 mesh by use of an agate mortar. Their diffraction patterns were then obtained by means of a Philips 'Norelco' X-ray spectrometer having automatic recording and covering a 45-degree Bragg angle. The same equipment was later employed to measure the intensity ratios of the working curves and the unknown samples. Agreement between the diffraction patterns obtained with filtered iron radiation, and the American Society for Testing Materials records for graphite, magnetite, and fluorite was satisfactory. The X-ray pattern for graphite was also checked against one obtained from a sample of well-crystallized Ceylon graphite. Fourteen standards containing 100, 80, 70, 60, 50, 40, 30, 20, 10, 7, 5, 3, 0·5 and 0·1 per cent graphite by weight were prepared by use of an analytical balance. The total weight used in all cases was 1·6700 gm. The internal standard, fluorite, was 0·4 of this value or 0·67 gm. The McCreery[6] technique was used in preparing the standards and in operating the spectrometer to minimize erratic results due to the platy nature and preferred orientation of graphite. All compact thicknesses were checked to ensure that 'effectively infinite' thickness[7] had been obtained. Magnetite was included in the standards because qualitative X-ray work had shown that the unknown material contained considerable triferric tetroxide (Fe_3O_4).

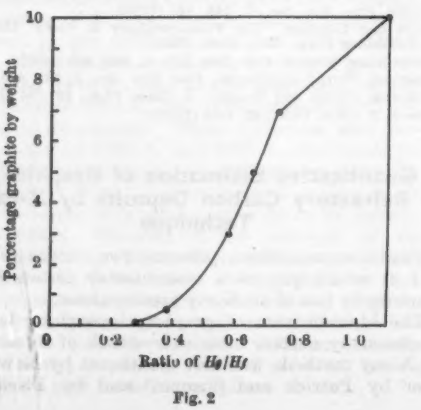

Fig. 2

The working curve of Fig. 1 covers the entire range of graphite content. When work was started on the unknown samples, however, the graphite content was found to be small. Fig. 2 was prepared, therefore, covering the range 0·1–10 per cent graphite by weight. In both curves, the ordinate is per cent graphite (by weight) obtained from the known composition of the standard. The abscissa H_g/H_f is the ratio of the height above background of the strong graphite line H_g at a wave-length of 3·38 A. to the corresponding height of the neighbouring fluorite line H_f at 3·16 A. Each point on the curve represents the average of at least ten separate measurements. The point representing 0·1 per cent graphite weight is the average of sixteen measurements. It was realized that use of automatic recording would limit the relative accuracy of graphite estimation to ± 10 per cent by weight, but no counting equipment was available.

The working curves were used to determine the percentage of graphite by weight in eleven large samples of carbon deposits produced by carbon monoxide attack on fired refractory specimens. The ceramic pieces were dry pressed from chemically analysed North Carolina and Florida kaolins to which chemically pure and spectroscopically checked Fe_2O_3 was added. Firing temperatures ranged from 1,110 to 1,260 deg. C. Tests for resistance to carbon monoxide attack were carried out in a cylindrical non-catalytic 'Inconel' chamber in accordance with the procedure recommended by the American Society for Testing Materials[8]. During the carbon monoxide attack, temperatures between 500 and 550 deg. C. were used.

The results obtained showed that the graphite content in the eleven unknown samples ranged from less than 0·1 to 9·4 per cent by weight. Magnetite was estimated on a semi-quantitative basis by comparison of the height above background of the 2·53-A. line for triferric tetroxide in the unknown with the height of this same diffraction line in the fourteen standards. The magnetite content ranged from less than 20 to approximately 100 per cent by weight. Because the powder compacts were required to have 'effectively infinite' thickness, it was necessary to use a minimum weight of carbon deposit of 0·375 gm. This requirement severely limited the number of samples which could be analysed.

Two other features of this method deserve brief mention. The first is the estimation of graphite in amounts as small as 0·1 per cent by weight. It is a fundamental principle that a good reflector of radiation is a poor absorber. The mass absorption coefficients calculated from data in Internationale Tabellen[9] for the three materials are: graphite, 10·73; magnetite, 59·55; and fluorite, 178·05.

The second feature is the departure of the working curve from a straight line below a value of 7 per cent graphite by weight. The internal-standard theory predicts both this departure and the curvature observed. The curvature is due mainly to counter

'dead time' during automatic recording for which there is no practical correction. When manual scanning was used, and a correction was made for dead time, Klug and Alexander verified that only three primary standards yielded an accurate straight line over the entire weight range in quartz/fluorite mixtures. The only way to obtain an accurate curve with automatic recording is to plot more points: fourteen standards were necessary for the curves shown in Figs. 1 and 2. Similar results in the detection of small percentages by weight and in the departure of the working curve from linearity have been reported by Carl[10], who used the same type and model of X-ray spectrometer with automatic recording on quartz/beryllium oxide mixtures.

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Intensification of the Photographic Image

THE overall quantum yield for the production of developable silver in the silver halide grains of a fast photographic emulsion struck by light is of the order of 10^9. I have found that the catalytic effect of the exposed silver halide grain can be increased by a factor of one million by utilizing the amplification available in chain polymerizations.

Aromatic amines used as photographic developers pass through a semiquinone or free radical state in the course of their oxidation[1,2]. In some cases the free radical will initiate the polymerization of vinyl monomers. Thus, as each silver atom is produced, a semiquinone radical is formed which will initiate a chain reaction with a kinetic chain-length of as great as one million so that the overall quantum yield is 10^{15}. Not all aromatic amines will initiate polymerization when oxidized; in fact, the majority are polymerization inhibitors under alkaline conditions[3]. I have found, however, that polymerization of vinyl compounds is initiated when silver halide crystals struck by light are placed in contact with *p*-aminophenol at *p*H 8·0. The exposed crystals without developer will not initiate polymerization.

A suspension of silver bromide crystals (average size about one micron) was made up in water using a trace amount of glue as the stabilizer. The suspension was exposed to blue light and then divided into two parts. One part was developed with a 1/10 *M* solution of *p*-aminophenol hydrochloride buffered at *p*H 8·0 and the other was developed with the same solution but which also contained 20 per cent by weight of calcium acrylate. After 15 min. the sample which was treated with monomer turned an intense black and a large precipitate finally settled out. The sample without monomer turned into a murky brown stable suspension. Suspensions which had not been exposed to light remained unchanged whether or not the developer solution contained monomer. Apparently the polymer produced serves to bind the exposed and developed crystals; this thereby exhibits a very dense image, since light scattering per unit weight of developed silver is considerably decreased on aggregation of the grains[4].

A variation of the above experiment was carried out with a photographic plate containing silver bromide crystals in gelatin gel. The plate was exposed to feeble light just sufficient to produce an image which was barely perceptible when developed by conventional means. When developed with *p*-aminophenol and monomer, together with a short warming at 35° C. to allow for mobility of the grains, an intense black image was produced. This intensification of the image was produced at the sacrifice of some resolution, however.

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The Clock Paradox in Relativity

As I have repeatedly pointed out, symmetrical ageing in this problem is an inevitable requirement of the postulate of relativity. I have given the argument in the simplest possible form[1] in order to facilitate refutation if it is indeed wrong. I therefore find it inexplicable that Sir Charles Darwin[2], while completely ignoring this argument (in which he is at one with all other critics), can write that "the accepted theory of relativity . . . quite definitely implies that a space-traveller will return from his journey younger than his stay-at-home twin brother". His reason for this assertion appears to be identical with that of Dr. J. H. Fremlin, on which I have already commented[3]. Since that comment appears to have been inadequate, I will consider the problem posed in more detail, in order to bring out what I believe to be the misconception underlying such arguments as that of Sir Charles Darwin.

The problem is this. S_0 and S_1 are originally together. S_1, by firing rockets, travels at uniform velocity V to and from a distant point. During their separation each sends out n light flashes per unit time by his clock, which the other receives. (In arguments, as distinct from illustrations, I prefer general symbols to numbers, to avoid accidental coincidences.) How many flashes does each send out and receive during the journey?

First let me state what is common ground. It is agreed that each observer receives 'slow' flashes at the rate $n\beta$, where $\beta = \sqrt{(c - V)/(c + V)}$ for a certain time, and then 'fast' flashes at the rate n/β until reunion. Apart from the conception of 'time-in-other-places' which is implicit in β, we agree not to introduce it further, so we let 0, t_0 and T_0 be the readings of S_0's clock at separation, at S_0's observation of the change from slow to fast flashes, and at reunion, respectively; while 0, t_1 and T_1 are the readings of S_1's clock at the corresponding times in his experience. It is then clear that S_0 will receive $n\beta t_0$ slow, and $(T_0 - t_0)n/\beta$ fast flashes, and will emit nT_0 flashes during the whole journey. There will be corresponding expressions for S_1's receipt and emission of flashes, and since every flash emitted by each observer is received by the other, we shall have the following equations:

$$\begin{aligned} n\beta t_0 + (T_0 - t_0)n/\beta &= nT_1 \\ n\beta t_1 + (T_1 - t_1)n/\beta &= nT_0 \end{aligned} \qquad (1)$$

After this we part company. I proceed in this way. Since, according to relativity, there can be nothing observable that will distinguish the motion of S_0 with respect to S_1 from the motion of S_1 with respect to S_0, we must have $t_0 = t_1$; otherwise, by comparing notes at the end, they would be able to distinguish between these equivalent expressions of the relative motion. This yields, from (1),

$$T_0 = T_1 = t_0 + \beta t_0 = t_1 + \beta t_1 \qquad (2)$$

that is, the two clocks read the same on reunion; each will receive slow flashes for a time t_0 and fast flashes for a time βt_0; and therefore each will receive $n\beta t_0$ slow and nt_0 fast flashes. The moment at which S_1 fires his rocket will be $T_1/2$ by his clock (we agree on this). Hence, since $\beta < 1$, it will be earlier than t_1; that is, S_1 will not observe S_0's flashes to change until after he has fired his rocket. This is a complete solution of the problem.

Darwin proceeds differently. He says first that t_1 is "certainly just half" T_1; that is, $t_1 = T_1/2$. Next, "the reversal" will occur at a time $T_0/2$ by S_0's clock, but at a distance $VT_0/2$ from him (time-in-other-places will keep breaking in), so he will observe it at a time $VT_0/2c$ after its occurrence; that is, $t_0 = \frac{1}{2}T_0(1 + V/c)$. Substituting these values of t_1 and t_0 in (1) we find:

$$T_1 = T_0\sqrt{(1 - V^2/c^2)} \qquad (3)$$

which is the usual asymmetrical result.

It is not difficult to see that Darwin's postulates are equivalent to the introduction of a fixed ether against which velocities are measurable. S_1 sees "the reversal" immediately, but S_0 only after an interval. That means that "the reversal" must be located at S_1 uniquely. Furthermore, since the distance which the light has to travel to S_0 is S_0's estimate of it, S_0 must be at rest in this ether: if he were moving towards or away from "the reversal", he would observe it earlier or later. Hence not only is the reversal located at S_1, but also the whole motion, to and fro, belongs to him, since S_0 is at rest. There is nothing in Darwin's argument (except the value of β) that would not have been wholly acceptable in the nineteenth century.

The relativity view is quite different. The only motions admissible are those of one body with respect to another. Hence "the reversal" cannot be assigned to S_1 as though S_0 did not exist: it must be the reversal of S_1 with respect to S_0 or of S_0 with respect to S_1, for there are no other observable bodies in the problem. Furthermore, these expressions of it must be equivalent. Hence the reversal cannot be located at S_1 rather than at S_0. It is a relation between the two bodies, a change from recession to approach, and not a property of one of them.

All this, of course, is only an involved way of expressing the simple argument already cited, on which a strange silence is maintained. Critics would save themselves many headaches if they would find the flaw in that instead of devising new ways of bypassing it.

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Corrugated Iron Pan

The morphology of lateritic and ironstone concretions is generally attributed to soil texture[1], ground-water movements[2,3] and variations in the soil aggregates upon which deposition takes place[4,5].

That the mechanical properties of such deposits may also affect their ultimate structures is suggested by an iron pan found on a cutting at Pulau Bukom, an island four miles south-west of Singapore.

When first seen, the cutting lay at an angle of 70°, exposing a gravel to sandy loam soil derived from parental conglomerates. A subsequent visit about a year later showed that an iron pan had developed over the lower slopes of the cutting as a hard, dark-brown carapace, 1–4 in. thick (Fig. 1). The pan was homogeneous, unlayered and had no structures indicating rhythmic deposition. Its inner surface adhered to the underlying soil without ramifications but its outer surface was corrugated into numerous sub-parallel ridges $\frac{3}{4}$–1 in. high, each of which was fissured along its crest to a similar depth.

These features suggest a rapid initial outflow of ground-water from the freely drained soils, which deposited a continuous plastic sheet, perhaps of limonitic composition, on the surface of the cutting. The high angle of the face and the weight of the

Fig. 1

deposit initiated slumping and folding of the plastic sheet into its present form; the fissures correspond to tensional faults of anticlinal folds. Afterwards dehydration converted the original material into the existing rigid and impervious pan, thus inhibiting further development.

The evidence indicates that if rapidly accumulated, ferric oxide deposits may pass through a plastic phase before induration. The process may account for concretionary and vesicular structures of certain lateritic horizons, and is being investigated for a future report.

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Dating of some Minor Intrusions of Ayrshire

AMONG the alkaline igneous rocks of Ayrshire are two groups of minor intrusions the age and genetic relations of which have aroused considerable interest in the past. The 'kylites' and 'crinanites' of Tyrrell[1] were originally classified together and were thought to be differentiates of the same magma, but later work by the Geological Survey (MacGregor[2]) has suggested that this may not be the case.

Kylites are olivine-rich theralites and essexites which frequently contain polysomatic clusters of purplish augite and only small quantities of analcite. The 'crinanites' are characterized by poikilophitic texture, an abundance of analcite, the presence of coarse, leucocratic segregation-veins (analcite–syenite of Tyrrell), and the frequent occurrence of accessory hornblende which is very rare in the kylites.

The Permian age of the kylites is fairly well established, as the majority of them are intruded into Coal Measures and two sills of the group are pierced by Permian volcanic necks. Fragments of kylitic rocks have been found in Permian necks, and the group closely resembles, both chemically and mineralogically, the Permian lavas of the Mauchline Basin.

Field evidence regarding the age of the 'crinanites' is not so conclusive, but similar intrusions on Arran are regarded as Tertiary. Mining evidence has suggested that a sill at Prestwick may be pierced by a small volcanic neck similar in type to the Permian necks around Dalmellington, but at Mauchline, a member of the group cuts sandstones above the Mauchline lavas. Crinanitic dykes trending north-west are thought to be connected with the Tertiary centres of Mull and Arran.

Since both the Permian and Tertiary directions of magnetization are well known in Britain (Creer *et al.*[3]), more than forty specimens, including typical representatives of both petrological groups, were collected, and a palæomagnetic study of the directions of permanent magnetism was made using a simple astatic magnetometer. The dual classification based on petrology was confirmed. The Permian age of

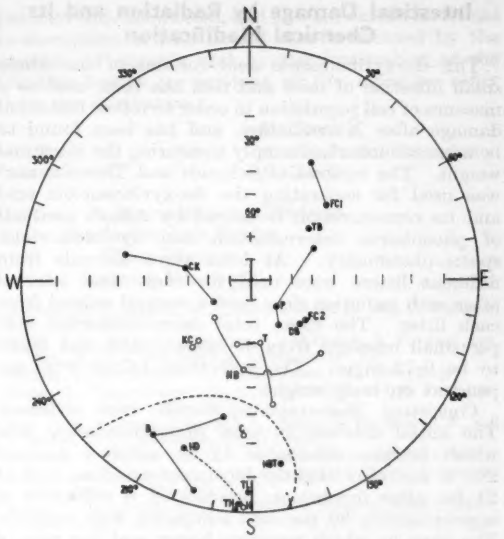

Fig. 1. Stereogram showing directions of magnetization of Ayrshire intrusions:
Specimen localities. *Kylitic group*: *B*, Benbeoch; *HD*, Hallyards Qy.; *H*, Hillhouse Qy.; *TH*, Tappet Hill; *C*, Crawfordjohn (essexite).
Crinanitic group: *FC*1 and *FC*2, Fisherton Cottage (dykes); *DB*, Dippol Burn; *TB*, Trabboch Burn; *KC*, King's Cross Point (Arran); *T*, Troon; *P*, Prestwick; *HB*, Howford Bridge.
Unclassified: *TL*, Tarbolton Station (Mauchline lavas); *CK*, Carskeoch; *HBT*, Howford Bridge (tuff).
The dotted line encloses Permian points. ●, North-seeking pole pointing downwards; ○, north-seeking pole pointing upwards; +, theoretical dipole

the kylites was verified (the mean directions of magnetization calculated using Fisher's[4] statistics gave a declination of 181° and an inclination of + 7° compared with the Du Bois unpublished result of 180° and − 4° for the Mauchline lavas) and the 'crinanites' gave a direction of magnetization consistent with a Tertiary age. Evidence of reversals suggests intrusion at different times within the Tertiary, although the time interval may not be great.

Some of the samples were partially stable magnetically, particularly those from the Craigs of Kyle (kylitic group), which initially gave directions suggestive of a Tertiary age, but on partial demagnetization (which removed the isothermal remanent magnetization) gave directions consistent with a Permian age. Other specimens subjected to the same treatment were unaffected and therefore considered stable.

Thanks are due to Northumberland County Council for a grant towards research of which this work is a part, to the Physics and Geology Departments of this College for the use of apparatus, and to Dr. A. E. M. Nairn for making the majority of the measurements.

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Intestinal Damage by Radiation and its Chemical Modification

The deoxyribonucleic acid content of the whole small intestine of mice and rats has been used as a measure of cell population in order to follow intestinal damage after X-irradiation, and has been found to be more reliable than simply measuring the intestinal weight. The method of Schmidt and Thannhauser[1] was used for separating the deoxyribonucleic acid and its concentration measured by Allen's method[2] of phosphorus determination and by ultra-violet spectrophotometry. At least three animals from different litters were used for each time interval after each radiation dose, and a control animal from each litter. The mean total deoxyribonucleic acid per small intestine from 43 control mice was found to be 0·72 mgm. The individual values were dependent on body-weight.

Consistent dose-response curves were obtained. The initial decrease in total deoxyribonucleic acid which became detectable 12 hr. after a dose of 200 r. was only slightly dependent on dose, and at 24 hr. after irradiation represented a reduction of approximately 30 per cent compared with controls. The time at which recovery began and the rate of recovery were markedly dependent on dose over the range 200–5,000 r.

Intraperitoneal injection into mice of β-mercaptoethylamine ('Becaptan') in doses of 150 mgm./kgm. 2–5 min. before X-irradiation significantly reduced the effect of 1,000 r. on intestinal deoxyribonucleic acid content 2, 3 and 4 days later to the same order as that of 750 r. (Table 1). Similar results, using 100 mgm. 'Becaptan'/kgm., were obtained in rats. The reduction of deoxyribonucleic acid content throughout the time 1–5 days after irradiation was greater than in mice, in agreement with the greater radiosensitivity of the rat intestine as judged by the clinical picture.

Mechanisms suggested for the action of 'Becaptan' are the promotion of regeneration without a concomitant reduction in the initial damage, or the reduction of initial damage without an effect on recovery[3]. When the time at which recovery begins and the rate of recovery are dependent upon dose, as in the intestine, bone marrow and lymph-nodes, the distinction may be easily confused, for a reduction in the degree of initial damage will show itself in an accelerated recovery, as illustrated in Table 1. A comparison on day 4 of the effects of 1,000 r. and 1,000 r. preceded by 'Becaptan' might suggest a marked enhancement of recovery by the drug. However, when account is taken of the time course of events after different doses it is clear that 'Becaptan' reduced the damaging effect of radiation by 25 per cent or a little more without intrinsically altering the course of recovery. This degree of effect is in quite good agreement with that given by Salerno[4] for the protective effect of 'Becaptan' on mortality in mice.

Table 1. Total Deoxyribonucleic Acid in Mouse Small Intestine

Mean values (mgm.) ± S.E. Figures in parentheses are numbers of animals used.

Days after X-ray	750 r.	'Becaptan' before 1,000 r.	1,000 r.	1,000 r. followed by 'Becaptan'
2	0·48 ± 0·02 (6)	0·48 ± 0·01 (4)	0·43 ± 0·02 (7)	0·40 ± 0·01 (4)
3	0·42 ± 0·02 (5)	0·47 ± 0·03 (3)	0·30 ± 0·01 (8)	0·27 ± 0·01 (3)
4	0·67 ± 0·02 (8)	0·76 ± 0·04 (4)	0·45 ± 0·05 (3)	
5	0·61 ± 0·06 (3)		0·56 ± 0·06 (3)	
6			0·61 ± 0·01 (4)	

After the recent report by Nerurkar and co-workers[5] the effect on deoxyribonucleic acid content of 1,000 r. with and without previous injections of methionine was determined, but neither in intestine, spleen, bone marrow nor liver could any protective effect be detected. The determination of total deoxyribonucleic acid in an organ or tissue provides a possible screening test for substances which might modify the effects of radiation. It has the advantages over the test commonly used with acute killing as the end-point of giving a result in less than a week, and of providing, with very few animals, a quantitative measure of any modification produced.

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Isotopic Tracer Method for measurement of Iron lost into and re-absorbed from Gastro-intestinal Bleeding Lesions

It has been shown[1,2], with the help of rabbit and sheep erythrocytes labelled with iron-59, that appreciable amounts of iron from hæmoglobin were absorbed when these cells were administered orally to human beings. So far as we know, no information is available on the re-absorption of hæm-attached iron from intestinal bleeding lesions. A method for measuring such a re-absorption is here proposed.

Approximately 10 microcuries of iron-59 in the form of ferric ammonium citrate (from Abbott Laboratories, Oak Ridge) are injected intravenously. Blood radioactivity is determined on the subsequent days until a plateau is reached. A 20 c.c. aliquot of blood is then marked with 60 microcuries of chromium-51 and reintroduced in the patient's circulation[3]. Fæces are collected quantitatively in three 4-day periods, and blood obtained at the start of each period. Fæces are homogenized and prepared as previously described[4], and radioactivity from chromium-51 and iron-59 determined separately, with appropriate corrections[5], in a well-type scintillation counter (Nuclear-Chicago model 3037-*B*) with a pulse-height analyser (Radiation analyser, Chicago-Nuclear). Blood taken at the beginning of each fæcal collection period serves as a standard for that period. The amount of blood B_i (in ml./day) which is lost into the intestine can be readily calculated for each 4-day period:

$$B_i = \frac{R_f \times Q}{R_b \times 4} \qquad (1)$$

in which R_f is radioactivity from chromium-51 in the 4-day stool, in counts per min. per gram of stool; R_b is radioactivity from chromium-51 in the blood obtained at the start of the 4-day stool collection, in counts per min. per ml. of blood; Q is quantity of stool in the 4-day period in gm.

The amount of iron lost into the intestine through the bleeding lesion Fe_i in mgm./day is then:

$$Fe_i = \frac{Hb \times B_i \times 3{\cdot}40}{100} \qquad (2)$$

in which Hb is blood hæmoglobin concentration, in mgm./100 c.c.; and 3·40 is mgm. of iron per gm. of hæmoglobin[6].

If in formula (1) we substitute for R_f the radioactivity in the stool due to iron-59, and for R_b the radioactivity in the blood due to iron-59, we obtain the value B_f, which is the quantity of blood, in c.c./day, which contains an amount of iron equivalent to that lost in the fæces. Substituting the value of B_f for B_i in formula (2), we obtain Fe_f, the amount of iron, in mgm. lost per day in the fæces. Then

$$Fe_r = Fe_i - Fe_f$$

where Fe_r is the amount of iron re-absorbed in mgm./day.

It has been shown that chromium-51 attached to red blood cells is not significantly re-absorbed when it is placed in the gastro-intestinal tract of dogs and rats[7] and of humans[8].

Practically speaking, it may be said that comparison of radioactivity in stools and blood of patients with circulating erythrocytes marked with chromium-51 is a valid way of estimating the quantity of blood lost into the gastro-intestinal tract from a bleeding lesion.

Comparison of radioactivity from iron-59 in blood and stool gives us the quantity of iron lost in the stool. A minimal part of this iron, of the order of no more than 1 mgm./day[8], will represent the normal daily iron lost by the patient, and hence cannot be taken as coming from the bleeding lesion. The exact quantity could be calculated for each patient by measuring radioactivity in a stool before the erythrocytes are tagged with chromium-51. In any event, this cause of error would weight the balance on the side of apparently less iron re-absorbed than is correct.

The method has been tested thus far in four patients who harboured varying numbers of hookworms, since this represents a fairly constant daily source of bleeding[4]. The results may be seen in Table 1. In all these patients, the percentage of iron from hæmoglobin which is re-absorbed appears to be surprisingly high.

It will be of interest to study whether such a high degree of re-absorption is characteristic only of patients with hookworm, and to what extent intestinal re-absorption of hæm-bound iron is affected by the presence of anæmia and by the localization of the bleeding lesions in portions of the intestine other than the duodenum.

Table 1. Iron lost into and re-absorbed from the Gastro-intestinal Tract in Patients with Hookworm Infection

Patient	No. of ova in stools (thousand/day)	Blood hæmoglobin (gm./100 c.c.)	Iron loss* Intestinal (mgm./day)	Iron loss* Fæcal (mgm./day)	Iron re-absorbed* (mgm./day)	Iron re-absorbed* (per cent)
F. A.	2,798	9·0	13·6	3·2	10·4	76·4
L. N.	2,411	4·0	4·3	2·7	1·6	37·4
F. R.	5,392	6·4	7·5	4·3	3·2	42·5
C. O.	590	8·4	6·1	2·9	3·2	52·5

* Average from three 4-day study periods

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Radioactivity of Blood Carbon Dioxide in Animals oxidizing Glucose labelled with Carbon-14 and Other Labelled Substances

The rate of appearance of radioactive carbon dioxide in the expired air following the administration to an animal of a carbon-labelled oxidizable material has been widely used in making calculations of the rate of degradation of the particular material[1,2]. However, it is evident that, before isotopic carbon introduced into the body in this way can be excreted in the expired air, a number of physical processes must have intervened, quite apart from the chemical transformations which are involved. These physical processes include the passage of the original substance through the blood and tissue fluids, its mixing with unlabelled molecules of the same species and also the subsequent transport of the carbon dioxide produced at the sites of oxidative reactions to the alveoli of the lungs. The factors which determine the rate of elimination of radioactive carbon dioxide from the animal body have in particular received theoretical treatment[3].

In the experiments described here we have attempted to follow the catabolism of a labelled substance in different organs of the body by taking simultaneous samples of arterial and venous blood from those organs and examining the specific activity of the carbon dioxide entering and leaving the different vascular territories. We did not measure blood-flow, so that our results are in this sense qualitative; but they do reveal certain interesting differences between the various organs studied. Glucose was the substrate in the majority of our experiments, which were conducted on dogs and monkeys. In most cases the animals were under pentobarbitone anæsthesia, but some measurements have also been made under thiopentone, which is less suspect in terms of its effects on carbohydrate metabolism. Fig. 1 shows the results of comparing the specific activity of the carbon dioxide of arterial blood with that of blood taken from a number of sites in the venous system

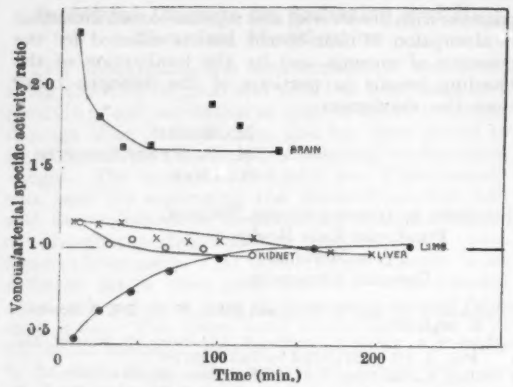

Fig. 1. Venous/arterial specific activity ratios of carbon dioxide for different organs after injection of ^{14}C-glucose. (The curves joining the observed points were drawn by eye solely as visual aids and no special importance attaches to their precise shape)

after injecting intravenously glucose labelled with carbon-14. Usually only one area of venous drainage was sampled in any one animal, but where simultaneous checks from more than one area were possible the results confirmed the accuracy of the composite picture built up from observations on separate animals. Moreover, the trends shown in Fig. 1 were all consistently present in a number of experiments. The lesser circulation has little effect on blood carbon dioxide specific activity; the specific activity curves of the carbon dioxide in systemic arterial blood, mixed venous (pulmonary arterial) blood and expired air have been found to be identical from the end of the third minute following ^{14}C-bicarbonate injection. This identity might reasonably be expected on the basis of data available from conventional studies of respiratory exchange[4]. The ratio of venous to arterial specific activity from blood circulating through the brain, liver and kidneys (Fig. 1) is also what might be expected from a *prima facie* consideration of the consequences of oxidation of a labelled substrate, that is, the venous carbon dioxide is more heavily labelled than the arterial. The general form of our curve for brain is in good agreement with a

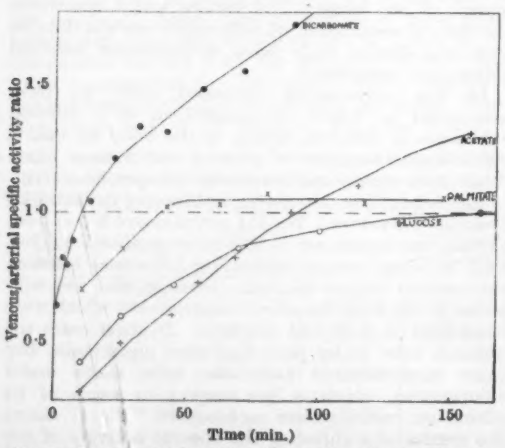

Fig. 2. Venous/arterial specific activity ratios of carbon dioxide in the dog's hind-limb following injection of various ^{14}C-labelled substrates. (Curves drawn by eye as in Fig. 1)

similar observation on human brain recently described by Sacks[5]. The curve (Fig. 1) of the changes in the venous/arterial specific activity ratio in the hind-limb, however, presents a totally different appearance from that of the other organs studied, since in the first 2½ hr. after ^{14}C-glucose injection the venous carbon dioxide has a lower specific activity than the arterial. This effect cannot be attributed solely to the production of unlabelled carbon dioxide from other substrates, since the difference in total carbon dioxide content between venous and arterial blood (about 3 m.mol./l.) was insufficient to account quantitatively for the ratio. The reduction in specific activity of the venous as compared with the arterial carbon dioxide in the limb must, therefore, be explained by exchange with a large pool of unlabelled carbon dioxide which is held in the tissues of the limb and is in diffusional communication with the blood carbon dioxide. (The term 'carbon dioxide' is used in this context to include associated or dissociated carbonic acid.) We confirmed that such an exchange takes place by injection of $NaH^{14}CO_3$ into dogs, an example of the results from the limb in one such experiment being given in Fig. 2.

While the experiments with ^{14}C-bicarbonate provide a basis for understanding the reduction of the specific activity of the arterial blood as it passes through the limb in the absence of production of metabolic $^{14}CO_2$ they provide only a partial analogy with those in which the animal had been injected with ^{14}C-glucose. The fact that under these latter conditions the specific activity of the blood from the limb veins continues below that of arterial blood suggested that in the resting limb blood glucose does not undergo rapid oxidation. This conclusion would be in conformity with the findings of Andres, Cader and Zierler[6], who have demonstrated by non-isotopic methods that only some 7 per cent of the oxidative metabolism of the resting human forearm is based on glucose.

In an attempt to identify other possible substrates for the oxidative activity of the resting limb we injected 1-^{14}C-acetate and 1-^{14}C-palmitate. The changes in venous/arterial specific activity ratio in these experiments are indicated in Fig. 2. Although the ratio approached unity more rapidly than in the case of glucose it was still less than 1 for some 40 min. in the case of palmitate where the rise was most rapid. It thus appears that, whichever labelled substance is injected, in the early stages the specific activity of the blood carbon dioxide falls during the passage through the dog's hind limb because of the dominating influence here of the large tissue pool of unlabelled carbon dioxide. Drury, Wick and Almen[7] calculated that in rabbits 80 per cent of the (readily exchangeable) body carbon dioxide is present in muscle and skin and that after injection of ^{14}C-bicarbonate the carbon dioxide of these tissues reaches the same specific activity as that of the arterial blood less rapidly than does the carbon dioxide of liver. Our results suggest a similar distribution of exchangeable carbon dioxide in dogs. In the limb the diluting effect of the unlabelled carbon dioxide pool in the tissue (which includes bone) greatly outweighs the effect of newly produced metabolic carbon dioxide on the arterio-venous specific activity difference. This makes identification of the energy source difficult on carbon dioxide analyses alone.

The present results demonstrate rather forcibly that when the specific activity of carbon dioxide is measured in the expired air of an animal metabolizing

carbon-labelled material the specific activity found will be considerably lower than that of the carbon dioxide leaving those organs where oxidation of the labelled substrate is most active.

It is hoped to publish a fuller account of these experiments in the near future.

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Chromatography of Tobacco Mosaic Virus on a Cellulose Cation Exchange Adsorbent

Chromatographic procedures for tobacco mosaic virus using filter paper sheets[1,2] and starch columns[3] have been reported. Recently, cellulose ion-exchange adsorbents have been used for the chromatographic separation of serum proteins[4,5].

In the work reported here carboxymethylcellulose powder was prepared following the method of Peterson and Sober[4] and was used in experiments with extracts from tobacco-mosaic-infected Turkish tobacco plants. 30 gm. of infected Turkish tobacco leaves were frozen and ground in an 'Omni-Mixer' with 100 ml. of a mixture of 0·1 *M* acetic acid and 0·1 *M* sodium acetate having a *p*H value of 3·0. The *p*H of the blended mixture after grinding was 3·7. The liquid was separated from the fibrous constituents by pressing through cheese-cloth and was then centrifuged at 10,000*g* for 10 min. The sedimented material from this run was resuspended in 50 ml. of distilled water by grinding again in the 'Omni-Mixer'.

During this second grinding enough sodium phosphate salt was added to adjust the *p*H of the mixture to 7·0. This neutral mixture was centrifuged a second time at 10,000*g* for 10 min. This time the pellets were discarded and the supernatant liquid was saved and used as the sample material for chromatographic experiments. This liquid was opalescent and showed strong birefringence, typical of concentrated tobacco mosaic virus solutions, when viewed through crossed polarized filters.

A 2·5 cm. × 32·5 cm. chromatographic column was prepared and conditioned by the passage of 250 ml. of 0·005 *M* citric acid (*p*H 3) prior to the application of the sample. 4 ml. of sample was applied to the column. The column was then developed with 150 ml. of 0·005 *M* citric acid having a *p*H of 3·0. Next an elution schedule which gradually increased the *p*H and salt concentration was followed. The starting solution consisted of 200 ml. of 0·005 *M* citric acid in a constant-volume mixing flask. Mixing was achieved by a magnetic stirrer as solutions were added to the mixing flask in a dropwise manner with the rate of addition being controlled by the column elution rate.

A closed-system siphon was used for transferring liquid from the bottom of the mixing flask to the top of the column. The complete elution schedule was as follows:

In mixing flask	200 ml.	0·005 *M* citric acid (*p*H 3)
Solution I	150 ml.	0·005 *M* citric acid (*p*H 3)
Solution II	200 ml.	Mixture, 1 pt. 0·02 *M* citric acid : 1·45 pts. 0·02 *M* Na_2HPO_4 (*p*H 5)
Solution III	200 ml.	0·02 *M* Na_2HPO_4 (*p*H 9)
Solution IV	200 ml.	0·05 *M* Na_2HPO_4 (*p*H 9·05)
Solution V	200 ml.	0·05 *M* Na_2HPO_4 − 0·02 *M* NaCl (*p*H 9·05)
Solution VI	200 ml.	0·05 *M* Na_2HPO_4 − 0·05 *M* NaCl (*p*H 9·05)
Solution VII	400 ml.	0·05 *M* Na_2HPO_4 − 0·1 *M* NaCl (*p*H 9·05)

The effluent was collected in 8-ml. fractions by an automatic fraction collector. Infectivity of the fractions was estimated using pinto beans as the assay host. Each fraction was assayed on one leaf on each of five different bean plants. The bean plants were given a 10-sec. dip in 50° C. water, dried, dusted with 'Carborundum', and then inoculated with 0·1 ml. aliquots from the fractions. The hot-water dip increases the sensitivity of the bean leaves to the virus[6].

The hydrogen ion concentration, electrical conductivity, optical density at 2600 A., and infectivity of the fractions are shown in Fig. 1.

The light-absorption curve had two major peaks: one occurred quite early in the elution schedule while the other occurred much later. The infectivity curve is the best average curve that can be drawn from the

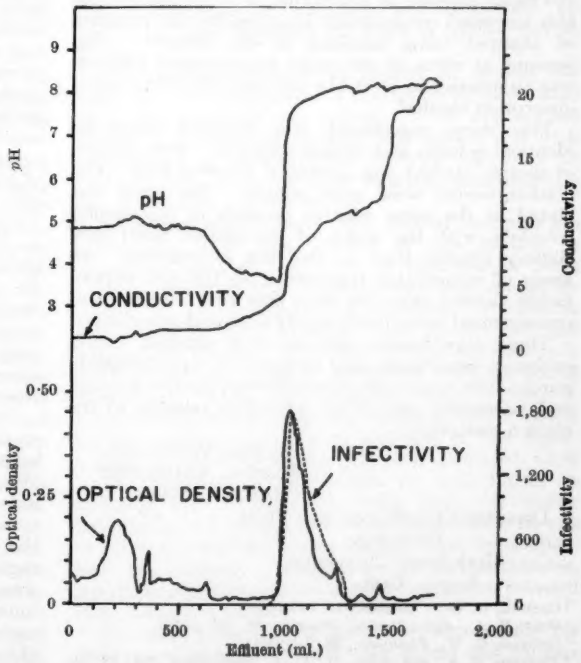

Fig. 1. Chromatography of a crude tobacco mosaic virus preparation on a carboxymethylcellulose column. Hydrogen ion concentration, electrical conductivity (millimhos/cm.^{5} at 25° C.), optical density at 2600 A. and infectivity (average of lesion counts on five bean leaves) are all plotted against volume of effluent. Effluent was collected in 8 ml. fractions

results of counting the lesions. As the curve of infectivity was almost coincident with the second light absorption peak, it was assumed that the absorption recorded in this portion of the elution schedule was principally that of tobacco mosaic virus. Ultra-violet absorption spectra of fractions in the major peak were typical of tobacco mosaic virus solutions. The nature of the absorbing components in the other peak has not been determined.

The *p*H of the effluent decreased gradually from a value of about 5 to 3·5 when the virus break-through occurred. This indicates that the lower part of the column had not reached an equilibrium with the *p*H 3 citric acid solution prior to the application of the sample. The *p*H of the effluent in the first virus-carrying fractions was 3·5. This *p*H value is assumed to be near the isoelectric point of the virus under the conditions existing on the adsorption column. It is believed that the virus can only be moved at *p*H values higher than its isoelectric point on a cation-exchanging adsorbent at the salt concentrations used.

It is significant to note that a marked break occurred in the *p*H curve at the point of virus elution. This break, amounting to four orders of magnitude, is probably a result of the buffering action of the virus protein.

There is also a significant break in the conductivity curve which lags slightly behind the break in the *p*H curve. This rapid change in conductivity cannot be accounted for in the gradual mixing of the salt-buffer developing solutions.

Because this rapid rise in conductivity is coincident with the rapid increase in ultra-violet absorption and the rapid increase in infectivity, it is concluded that this increased conductivity is caused by the presence of charged virus particles in the effluent. The amount of virus in the most concentrated fraction was calculated to be 0·014 per cent from the light-absorption results[7].

This same experiment was repeated using an identical column and elution schedule. The amount of sample applied was increased fourteen-fold. The elution results were quite similar. The virus was eluted at the same relative position in the elution schedule, with the width of the elution band only slightly greater than in the first experiment. An assay of comparable fractions from the two experiments showed that the virus was 10–15 times more concentrated in the fractions of the second experiment.

These experiments indicate that cellulose cation exchange adsorbents may be useful in virus isolation, particularly where *p*H, conductivity, optical density, and infectivity can all be studied in relation to the elution patterns.

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Methionine Biosynthesis and Utilization in *Pseudomonas tabaci* and *Ps. angulata*

Pseudomonas tabaci, the wildfire bacterium of tobacco, produces an exotoxin, detectable by a bacteria-free, chlorotic halo surrounding the necrotic focus of infection in the leaf at the site of inoculation; *Ps. angulata*, the causative agent of angular leaf spot of tobacco, does not produce the chlorotic halo. These species are indistinguishable when *Ps. tabaci* is attenuated and no longer produces the exotoxin[1]. Since the exotoxin behaves as a methionine anti-metabolite for the host cells[2], the effect of a second methionine antimetabolite, methionine sulphoximine, on toxigenic strains of *Ps. tabaci* was determined. Furthermore, eighteen independently isolated, methionine-requiring mutants of this species were tested to establish the site of the block in the biosynthetic pathway for this amino-acid.

Two strains of *Ps. tabaci* (*R*2 and *S*3) and one strain of *Ps. angulata* (62*B*), kindly supplied by Dr. H. E. Heggestad, U.S. Dept. of Agriculture, and Dr. A. C. Braun, Rockefeller Institute for Medical Research, respectively, were used. All strains were grown in a synthetic medium[3] which was solidified with Noble agar ('Difco') whenever a solid medium was required. Mutants of *Ps. tabaci* requiring methionine were isolated following ultra-violet irradiation and screening with penicillin[4].

None of the methionine-requiring mutants of *Ps. tabaci* responded to supplementation with the inorganic precursors (sulphur, sulphite, thiosulphate) or with the organic precursors (cysteine, homoserine, cystathionine, homocysteine) known to be involved in the biosynthesis of methionine in *Escherichia coli* and *Neurospora crassa*. One mutant was especially interesting, since it required both cysteine and methionine in a specific molar ratio. In the course of using crystals of the organic precursors of methionine as auxanographic supplements on the surface of plates seeded with the mutants it was noted that all mutants were strongly inhibited by cysteine and homoserine. The two parental strains of *Ps. tabaci* and the one strain of *Ps. angulata* were also inhibited by cysteine and homoserine.

Crystals of methionine sulphoximine were seeded on the centre of plates the surface of which had already been covered with cells of either *Ps. tabaci* or *Ps. angulata*. Both strains of the former species were resistant and one strain of the latter species was sensitive, displaying a large zone initially with no colonies in the region of the crystals. This response appears to be a second criterion for distinguishing these species.

During the investigation of the toxigenicity of the methionine-requiring mutants of *Ps. tabaci*, it was noted that almost all mutants were not toxigenic. When prototrophic reversions of these mutants, now able to grow in the absence of methionine in the synthetic medium, were inoculated into leaves, only the two tested reversions from one mutant did not regain toxigenicity[4]. These non-toxigenic reversions were sensitive to methionine sulphoximine. Six, independently isolated, methionine sulphoximine-resistant mutants of *Ps. angulata* did not produce a chlorotic halo in tobacco leaves. Although it has been possible to 'convert' *Ps. tabaci* to *Ps. angulata*, it has not yet been demonstrated that *Ps. angulata* can be 'converted' to *Ps. tabaci*. It should be mentioned in this connexion that resistance and sensitivity

to methionine sulphoximine in *Chlamydomonas reinhardi* is controlled by a single gene difference[5].

These observations suggest that the biosynthesis and, perhaps, utilization of methionine in *Ps. tabaci* may not follow the familiar pattern found in *E. coli* and *Neurospora*, and that one of these species (*Ps. tabaci* and *Ps. angulata*) may be a variant of the other species.

This investigation was aided by a contract (*NR*135–267) between the Office of Naval Research, Department of the Navy, and the University of Chicago, and by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

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Isolation of Intact Liver Cells

Liver cells have been isolated by various methods, such as by forcing the tissue through stainless steel sieves[1], by tryptic digestion[2] and by incubation in acid solutions[3]. Anderson[4] obtained a high yield of cells by perfusion of liver with calcium-free solutions containing chelating agents (such as ethylenediamine tetraacetate (versene) or citrate) and subsequent dispersion.

From investigation of these and other methods, a technique has been developed[5] which permits the isolation of cells in high yield in physiological solutions without use of enzymes, chelating agents or abnormal *p*H.

Under ether anæsthesia the inferior vena cava of a mouse is cut fairly low down and the vessel is clamped with a hæmostat just above the point of entry of the left renal vein. The hepatic artery is severed and the liver is perfused via the portal vein with 10–15 ml. of fluid (see below) at 37° C. using a hypodermic syringe (20 ml.) and a No. 25 needle. During perfusion the pressure is gradually increased until the blanched liver is fully distended. The initial stages of perfusion must be accomplished before the heart actually stops beating. The liver is quickly removed from the animal and transferred to a vessel containing the perfusion fluid at 37° C., cut into fairly large pieces with scissors and very gently dispersed in about 5 vol. of the perfusion fluid at 37° C. using a glass tube and a 'Polythene' pestle constructed as described by Kamphausen and Morton[6]. The clearance between the pestle and tube is about 0·002–0·004 in. The pestle is operated by hand and generally about 20–40 slow up and down strokes are sufficient to disperse the cells. The dispersion is filtered through bolting nylon of increasing mesh (for example, 5*N*, 9*N*, 12*N*, 17*N*, 21*N* and 25*N*) to remove strands of connective tissue and clumps of cells. Fig. 1 shows that the suspension contains very little cell debris or broken cells. For many purposes the cells may be used directly in this suspension or they may be sedimented by low-speed centrifuging and washed as desired.

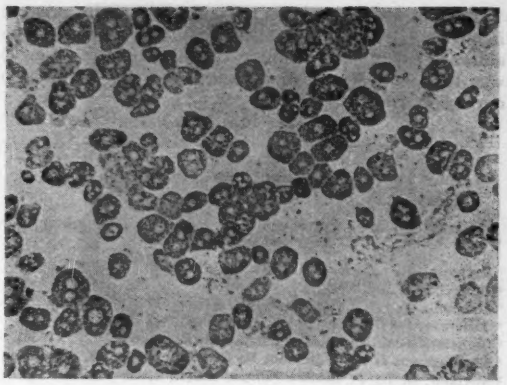

Fig. 1. Suspension of mouse liver cells isolated in calcium-free Locke's solution, as obtained directly after filtration. (× 140)

By this means cells have been consistently obtained with every perfusing fluid investigated, including 0·9 per cent (w/v) sodium chloride, calcium-free Locke's solution with and without versene, complete Locke's solution, 0·25–0·35 *M* sucrose solutions with or without 0·001 *M* magnesium chloride or 0·001 *M* calcium chloride, polyvinyl pyrrolidone–sucrose solution, and mouse serum. The most satisfactory preparations have been obtained from 7·3 per cent (w/v) polyvinyl pyrrolidone–0·25 *M* sucrose–0·001 *M* magnesium chloride at *p*H 7–7·4, a medium developed for isolation of intact mitochondria[7].

The ease of isolation of cells increases with increasing temperature of perfusion and dispersion up to 50° C.; but normally all work is carried out at 37° C.

This method enables conversion of almost the entire liver into isolated cells in a relatively short time after the death of the animal. With appropriate choice of hyperdermic syringe and needle, and with adjustment of the perfusion volume, cells may be isolated from livers of other animals, including the rat, the rabbit and the sheep.

Numerous studies have been carried out, and are continuing, with cells isolated in this manner to determine whether they may be regarded as being physiologically intact. Evidence has been sought by means of: (1) microscopic examination; (2) electron microscopy of thin sections; and (3) enzymic and respiratory studies. If unwashed, the isolated cells show a low but definite respiration without added substrates. This respiration-rate may be largely removed by preliminary cell washing, and restored to the washed cells by the addition of the supernatant in which they were originally prepared, after it has been made particle-free by centrifuging at 105,000*g* for 20 min. It seems that the higher respiration-rate of the unwashed cells is due to one or more factors which may be lost from the suspension by washing. These may include substrates, enzymic co-factors, or stimulating substances released from disrupted cells.

The same principle has been used successfully for isolation of intact cells from both kidney and tumour tissues. It is considered that suspensions of cells obtained as described here have many advantages over other types of preparations for studying biological reactions at the cellular level.

The details of these and related studies at present in progress will be described in further papers to be submitted for publication. The photograph (Fig. 1) was taken by Mr. E. Matthaei, to whom we wish to express our thanks.

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Rapid Extraction with Ethyl Acetate of Free Fluorescein Derivatives from Fluorescein *iso*Cyanate-Globulin Conjugates

The technique of staining tissues specifically with fluorescein-conjugated globulin has found wide application since it was introduced by Coons, Creech and Jones in 1942[1]. Though Coons and Kaplan[2] have recently introduced technical improvements the procedure remains in part tedious and time-consuming. Conjugation between fluorescein *iso*cyanate and protein is effected in a bicarbonate buffer (*p*H 9·0) in the presence of dioxan and acetone[3]; conjugation, however, is never quantitative and the presence of free dye in the protein solutions is inevitable. The free fluorescein derivatives must be eliminated since, when present in tissue sections being viewed with the fluorescence microscope, they impart a hazy appearance. At present the free fluorescein derivatives are removed from conjugates mainly by exhaustive dialysis and afterwards by adsorption with acetone-extracted or lyophilized mouse liver preparations. The dialysis is time-consuming, while in our experience prolonged adsorption with organ preparations removes specific conjugates as is shown by a fall in the antibody titre.

We have found that extraction of fluorescein-conjugated antisera with ethyl acetate at neutrality will remove from the reaction mixture both the free fluorescein derivatives and the acetone and dioxan. The following extraction procedure is used in this laboratory.

After the fluorescein *iso*cyanate and globulin have been allowed to react at *p*H 8–9 for 16 hr. at 0° C., the solution is extracted with 1 volume of ethyl acetate (A. R.) and the emulsion thus formed broken by low-speed centrifugation (1,000*g* for 5 min.). The supernatant acetate which contains the acetone and dioxan is discarded. The *p*H of the aqueous layer is then lowered to 7·0 (bromthymol blue) by the addition of *N* hydrochloric acid, and this solution extracted twice with 2 vol. of ethyl acetate. The supernatants are discarded and the dissolved acetate is removed from the aqueous phase *in vacuo* with a water pump.

During storage of either dialysed or acetate-extracted conjugated sera at − 10° C., there is a slow liberation of bound fluorescein derivatives which should be removed by a single acetate extraction before use.

Acetate extraction of serum globulin fractions did not affect the complement-fixing antibody titre of the rabbit and anti-rat-liver and anti-rat-kidney microsomal and mitochondrial sera which have been used in this laboratory.

While acetate extraction removes free fluorescein derivatives, it may be necessary, in addition, to adsorb the extracted serum with the appropriate heterologous antigen—often a dried acetone-extracted organ preparation[3] or a fresh particulate tissue fraction[5]—in order to yield a serum with the required specificity.

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Clearing Action of Lysolecithin

G. R. Webster has recently reported very interesting experiments on the clearing action of lysolecithin on brain homogenates[1]. Analogous findings with lysolecithin (and animal venoms) on brain brei suspended in physiological saline were published in 1942 by Grosse and Tauböck[2].

The solubilizing effect of lysolecithin may be observed also with suspensions of cholesterol, lecithin, oleic acid and particle preparations from liver[3] and on diluted egg yolk[4]. It may be connected with the high surface activity of lysolecithin[3].

Lysolecithin acts on enzyme systems, for example, of oxidative phosphorylation[5], succinoxidase system[6] and on tissue thromboplastin[4], possibly by disintegrating biological structures. Complete lysis of erythrocyte stroma[7] and changes of morphology of liver mitochondria[8] have been shown.

Lysolecithin has been sometimes thought to be involved not only in the normal or pathological turnover of blood cells (for review, see ref. 9) but also in pathological conditions of the central nervous system[10]. If lysolecithin, or the phospholipase *A* producing it, is present in the body, it may be very important for permeability and solubilizing processes of all kinds[3]. Knowledge of the presence of lysolecithin or phospholipase *A* in normal or pathological tissue, however, is very restricted.

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Isolation of the Bound Form of Nicotinic Acid

Chaudhuri and Kodicek[1] have shown that almost the whole of the nicotinic acid in cereal bran was present in a bound form. They concentrated this 'precursor' of nicotinic acid from wheat bran considerably. Chaudhuri[2], starting from rice bran in this laboratory, concentrated this substance about seventy times, following the concentration by the usual colorimetric method using *p*-aminobenzoic acid as the coupling reagent[3]. It has now been possible to isolate the bound form of nicotinic acid from rice bran in a crystalline state. This work has been facilitated by the observation that the active substance, when subjected to paper chromatography using phenol–water (80 : 20) as the solvent system, gave two ninhydrin-sensitive spots, one of which moved with the solvent front and produced a blackish-violet colour with ninhydrin. It also gave an orange colour when sprayed with *p*-aminobenzoic acid after exposure to cyanogen bromide vapour according to the method of Kodicek and Reddi[4]. The orange colour has been shown to be produced by the bound form, and it is insoluble in amyl alcohol, which dissolves the colour produced by free nicotinic acid as observed by Swaminathan[5]. A method developed by Das and Ghosh[6] based on this observation has been used to follow the concentration of the bound form of nicotinic acid in the present work.

The method of isolation consists of: (1) the extraction of rice bran with 0·1 *N* hydrochloric acid; (2) precipitating inactive material from the extract with 3 volumes of acetone; (3) centrifuging and precipitating the active material from the centrifugate with 3 volumes of a mixture of acetone and ether (2 : 1); (4) extracting the precipitate with 65 per cent alcohol and precipitating the active material from the extract with 12 vol. of acetone–ether (2 : 1) and repeating this process; (5) drying the precipitate, dissolving it in the minimum quantity of water, fractionating it on a cellulose column by treating the column with phenol–water (80 : 20) when the active material forming the brown zone moves with the solvent front, and collecting the brown phenol–water fraction; (6) precipitating the active substance from the phenol–water solution with 45 vol. of acetone–ether (2 : 1) in the cold; (7) washing the precipitate with acetone–ether, drying, dissolving it in the minimum quantity of cold water, and allowing it to crystallize in a vacuum desiccator in the cold.

The substance crystallizes in shining russet rectangular plates (Fig. 1). Several preparations showed the same crystalline structure, composition and activity. The yield is 50–70 mgm. per 100 gm. of rice bran. It decomposes above 225° C. It gives a blue fluorescence in ultra-violet light, which changes to yellowish-green on treatment with alkali, as was observed with their wheat-bran concentrate by Chaudhuri and Kodicek[1]. Dissolved in 0·1 *N* hydrochloric acid, it gives an absorption maximum at 262 mμ. Analysis of the substance gives the following figures: C, 47·41; H, 6·93; N, 11·65; S, 0·85 per cent. Molecular weight, as determined by the diffusion technique using a sintered 'Pyrex' glass crucible fitted with a fritted disk (grade *G*-3), has been found to be of the order of 7,000, which agrees fairly well with the theoretical molecular weight (7,200) calculated on the assumption that there is one molecule of nicotinic acid per molecule of the substance. Preliminary experiments indicate that it is a peptide bound with a nicotinic acid moiety.

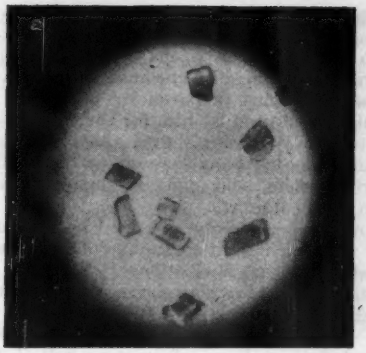

Fig. 1. Crystals of the bound form of nicotinic acid. (× 8)

In future communications this bound form of nicotinic acid, from which nicotinic acid is liberated by mild alkali treatment, will be referred to as 'niacinogen' for convenience.

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Chromatographic Characterization of Soluble Deoxypolynucleotides released in Mouse Spleen by X-Irradiation

In connexion with a programme of studies concerning the biochemical effects of whole-body X-irradiation on the deoxyribonucleic acid–protein complex of radio-sensitive tissues of the mouse, we wished to explore the nature of the soluble deoxypolynucleotides released in the spleen after exposure to the irradiation.

Previously reported evidence[1] indicates that following whole-body X-irradiation of mice at the *LD*100 dose-level (810–850 r.) there occurs a significant rise in free deoxypolynucleotide values from a pre-exposure level of 20 μgm. per spleen to a maximum of 350 μgm. per spleen (average value) 4–6 hr. post-exposure. This maximum value occurs at the same post-exposure time when the spleen weight is decreasing and the deoxyribonucleic acid–nucleoprotein content of the spleen is falling precipitously. These deoxypolynucleotides were characterized by their solubility in 0·14 *M* sodium chloride solution (deoxyribonucleic acid–nucleoprotein is insoluble in 0·14 *M* saline), insolubility in cold 0·2 *M* perchloric acid, ultra-violet absorption characteristics, positive Dische

diphenylamine reaction, and resistance to ribonuclease.

Main and Cole[2] have characterized calf thymus deoxyribonucleic acid by chromatography on calcium phosphate columns prepared by an earlier method of Tiselius[3] and used by him for the chromatography of proteins. We have shown that the short-term (30 min.) deoxyribonuclease-digestion products of deoxyribonucleic acid can be separated from the acid on such columns.

We now report results obtained by calcium phosphate column chromatography of the radiation-released deoxypolynucleotides. For the present studies, the calcium phosphate was prepared by a method[4] modified from the above. Dilute aqueous saline (0·14 *M* sodium chloride) extracts were prepared from spleens of young adult LAf_1 mice killed 6 hr. after whole-body X-irradiation, and also from non-irradiated mice as previously described[1]. A 100 per cent lethal X-ray dose was employed (810–850 r.).

In a typical experiment the spleens from six irradiated mice were homogenized in a few ml. of saline and then diluted to 16 ml. The resulting homogenate was centrifuged (5° C.) for 15 min. at 1,300 *g*. The absorbance at 260 mμ (A_{260}) of the resulting supernatant extract was 8·00. The A_{260} of a corresponding supernatant extract from four spleens of non-irradiated mice was 6·60. In an endeavour to equalize the amount of material absorbing at 260 mμ placed on each column, 4 ml. of the former were placed on one column, and 5 ml. of the latter were placed on another column.

Fig. 1*A* illustrates two elution histograms of the results derived from such spleen extracts after chromatography by continuous linear gradient elution with sodium phosphate buffer, *p*H 6·7. The peaks at the start of each chromatographic separation are of about equal magnitude and represent low molecular weight, that is, perchloric acid-soluble substances, presumably purine- and pyrimidine-containing compounds known to be present in these extracts[1]. Areas appearing between eluant phosphate concentrations of 0·08–0·100 *M* are of particular interest. A broad and characteristic elution band (between 0·07 and 0·10 *M*), with a sharp peak at 0·095 *M* is observed with the extract from irradiated mice. By contrast, no corresponding peak occurs with the spleen extract from non-irradiated mice, and furthermore the total 260 mμ-absorbance of substances eluted between 0·07 and 0·10 *M* is markedly lower.

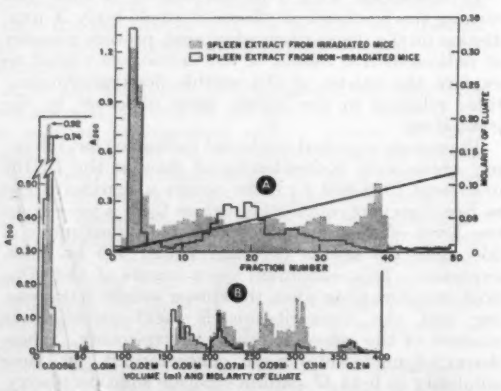

Fig. 1. Chromatograms of spleen extracts from X-irradiated mice and from non-irradiated mice eluted from calcium phosphate columns by sodium phosphate buffer, *p*H 6·7 in fractions of 4·5 ml. *A*, Chromatography by linear gradient elution; *B*, chromatography by discontinuous gradient elution

The results of discontinuous gradient elution chromatography of the spleen extracts (Fig. 1*B*) disclose the same general pattern as that obtained by continuous linear gradient elution. It is evident that the A_{260} of fractions eluted between 0·07 and 0·11 *M* phosphate buffer from X-irradiated mouse spleen extracts is considerably greater than that of corresponding eluate fractions from spleen extracts of non-irradiated mice. These eluate fractions from spleen extracts of X-irradiated mice give a positive test for deoxyribonucleic acid by Keck's method[5]. Further evidence that these 0·07–0·11 *M* phosphate eluants from irradiated spleens are macromolecular in nature comes from experiments[6] which show that calf thymus deoxyribonucleic acid exhibits similar chromatographic patterns on identical calcium phosphate columns. Macromolecular substances of lower molecular weight, for example, bovine serum albumin[6], as well as short-term deoxyribonuclease digests of deoxyribonucleic acid[2], were found to be eluted at lower phosphate concentrations, that is, 0·04–0·08 *M*. A typical monodeoxyribonucleotide (deoxyadenylic acid) was immediately and completely eluted from a column by 0·005 *M* phosphate buffer.

It will be of interest to determine the precise molecular weights of these polynucleotides released in the spleen following whole-body X-irradiation.

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Liberation of Tyrosine Hydroxyl Groups in Urea Solutions of Bovine Serum Albumin and Ovalbumin

The process of denaturation of proteins is being investigated in this laboratory by following changes in various properties which depend on the structure and the state of aggregation of the protein molecule[1]. In view of the possible importance of hydrogen-bonded tyrosine hydroxyl groups in maintaining the native configuration of the protein molecule[2] the liberation of tyrosine hydroxyl groups has been studied by examining the changes with time in the ultra-violet absorption spectra of bovine serum

albumin and ovalbumin under different conditions of *p*H, both in the presence and absence of urea.

The spectrum (above 255 mμ) of aqueous solutions of bovine serum albumin was found to be essentially independent of *p*H over the range 4·4–8·0 in the absence of urea. However, when the *p*H was adjusted to less than 4·4, the absorption peak at 279 mμ shifted instantaneously to lower wave-lengths and the spectrum more closely resembled that of free tyrosine. At *p*H 3·2 the peak had shifted to 277 mμ. No further shift in the peak occurred on decreasing the *p*H below 3. Differential absorption spectra were obtained by comparing the spectrum of the protein at *p*H values below 4·3 with that of the protein in neutral solution. At any given *p*H below 4·3 the difference in optical density was found to be greatest at 287–288 mμ. The difference at 287 mμ reached a maximum near *p*H 2·6. No further change occurred on decreasing the *p*H below 2·6 until *p*H 1·0 was reached, when there was some decrease in this difference in optical density. These changes in the spectrum are almost entirely due to changes in the environment of the tyrosine hydroxyl groups[2,3]. The change in optical density at 287 mμ closely parallels the increase in viscosity of bovine serum albumin at low *p*H reported by Tanford *et al.*[4].

On exposure of native bovine serum albumin to urea at concentrations above 2 *M*, over the *p*H range 4–9, an instantaneous shift of the absorption maximum towards 277 mμ occurred. The spectrum then resembled that of the protein in acid solutions below *p*H 3. Likewise differential spectra obtained by comparing the spectrum of the protein in urea solution with that of the native protein at neutral *p*H showed a maximum difference at 287–288 mμ.

Unlike bovine serum albumin, ovalbumin showed no change in the 280 mμ band over the *p*H-range 2·0–9·0 in the absence of urea. On exposure of ovalbumin to urea at concentrations greater than 4 *M*, a hypsochromic effect was observed. The extent of this effect varied with the *p*H, urea concentration and time of exposure to urea. The greatest shift observed was obtained by exposing the protein to 9 *M* urea at *p*H 3·1. The absorption peak under these conditions was shifted from 280 mμ for the native protein to 277 mμ for the denatured protein. Examination of differential spectra showed that the maximum difference in optical density occurred at 288 mμ. These spectral changes were very strongly dependent on the urea concentration.

The rate of liberation of the tyrosine hydroxyl groups in urea solutions of ovalbumin at *p*H 5·8 and 7·8 was studied by examining the rate of change of optical density at 288 mμ. At both *p*H values the rate has apparent first-order dependence. This observation may be compared with Harrington's studies[5] on the acid-base titration curve of ovalbumin in the presence of guanidine hydrochloride.

The rate of liberation of tyrosine hydroxyl groups in urea solutions of ovalbumin was a minimum near *p*H 8. This observation agrees with the finding of Simpson and Kauzmann[6] that ovalbumin has its maximum stability towards urea denaturation in the *p*H-range 7–9.

A comparison has also been made of the rate of liberation of tyrosine hydroxyl groups with the rate of change of other properties such as optical rotation. This and the present work will be published in detail elsewhere.

One of us (H. McK.) is grateful to Dr. A. G. Ogston and Prof. W. J. Kauzmann for helpful discussion during the course of this work.

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Determination of Chlorogenic Acid

Slotta and Neisser[1] found that *o*-dihydroxyphenolic compounds such as chlorogenic acid and caffeic acid could be oxidized quantitatively with an alkaline hypoiodate solution, and used this method for the determination of these acids in coffee. They found that for every mole of chlorogenic or caffeic acid, 10 gm.-atoms of iodine were required for complete oxidation and that the oxidation involved the aromatic ring only without affecting the side chain, This method has recently been used by Wilkinson. Phillips and Bacot[2] for the determination of chlorogenic acid in flue-cured tobacco. In their method the polyphenols were precipitated from an aqueous extract of tobacco with neutral lead acetate solution. The precipitate of lead salts was then washed with water to remove sugars, suspended in water and decomposed with hydrogen sulphide. Caffeic acid was removed by extraction with ether and chlorogenic acid estimated in the resulting solution by the above method[1]. This solution may, however, contain other substances which possess *o*-dihydroxyphenolic groups, such as rutin[3,4], *iso*quercitrin[5,6] and quercetin[5]. Wilkinson *et al.*[2] state without any proof that rutin did not interfere to any appreciable extent. Since these authors used their results for drawing conclusions about the quality of flue-cured tobacco, it was decided to investigate the action of alkaline hypoiodate on pure polyphenols which contained *o*-dihydroxyphenolic groups.

Chlorogenic and caffeic acids were recrystallized twice from water containing a trace of hydrochloric acid[7], and rutin, quercitrin and quercetin crystallized three times from aqueous ethanol (charcoal). After recrystallization the polyphenols were dried at 100° C./15 mm. for 6 hr.

Solutions containing 0·2 gm. of the appropriate polyphenol in 100 ml. of water were prepared. (In the case of the flavonols 1 ml. of a 2 *N* sodium hydroxide solution was added.) 5 ml. of the polyphenol solution, 10 ml. of 0·05 *N* iodine solution and 10 drops of 2 *N* sodium hydroxide solution were placed in a flask and the solutions well mixed. The flask was then stoppered and the reaction mixture allowed to stand in the dark for one hour. After acidification with 2 *N* sulphuric acid the liberated iodine was titrated with 0·05 *N* sodium thiosulphate solution using starch as indicator. Duplicate determinations and blanks were carried out at the same

Table 1

Polyphenol	Atoms of iodine/mol. of polyphenol
Chlorogenic acid (3-caffeoyl quinic acid)	9·94
Caffeic acid	10·05
Rutin (quercetin-3-rhamnoglucoside)	14·95
Quercitrin (quercetin-3-rhamnoside)	14·13
Quercetin	14·33

time and the amount of iodine consumed in the reaction found. No further increase in the amount of iodine consumed was found on allowing the reaction mixture to stand for two or three hours. The results are given in Table 1.

These results show that rutin and related compounds will interfere with the alkaline hypoiodate determination of chlorogenic acid. Not much work has been carried out on the estimation of flavonols in tobacco, but Turner[8] obtained a value of about 1 per cent for the amount of rutin in flue-cured tobacco. The amount of rutin present will vary from sample to sample, but taking this as an average value the error introduced in the chlorogenic acid content due to rutin alone is considerable. It would appear that a method for the determination of chlorogenic acid in tobacco would have to be based on the quantitative removal of other polyphenols, probably by paper chromatography and along the lines suggested by Paech and Ruckenbrod[9].

It is hoped to report other related work on this problem more comprehensively at a later date. Thanks are due to the Directors of the Imperial Tobacco Company (of Great Britain and Ireland), Ltd., for permission to publish this communication.

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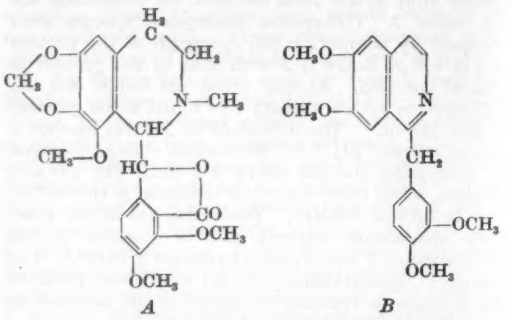
Determination of Papaverine and Narcotine by using Ammonium Reineckate

Methods of analysis of opium[1] and major opium alkaloids are required in determining the place of origin in those areas of the world where illicit traffic in opium arises. The Economic and Social Council of the United Nations in 1949 authorized research into devising chemical methods of identifying opium and invited member governments to participate in such a programme. Under this International Narcotics Research programme, Canada offered to train scientists from governments of other countries. This note is a publication of research results obtained by a U.N.T.A.A. fellow (L. K. T.) under this programme[2] and reports a new method of separating papaverine and narcotine.

Anneler[3] proposed the only satisfactory quantitative method of analysis of papaverine and narcotine, which are well known for their chemical similarities. The extractability of papaverine and narcotine from aqueous buffer solution of acetate was found to be similar which indicates the futility of attempting to separate this pair of alkaloids by ordinary countercurrent methods. Narcotine contains a lactone ring as shown in formula *A* compared with papaverine in formula *B*.



A *B*

Anneler's method is based on the splitting of the lactone ring by strong alcoholic potash followed by extraction of papaverine with chloroform from this alkaline solution. The narcotine is then recovered after ring closure using strong hydrochloric acid and subsequent extraction with benzene from an alkaline solution. Fulton[4] has employed this method in a unified analysis of opium for morphine, codeine, thebaine, papaverine and narcotine. In a recent study of this method low recoveries varying from 80 to 85 per cent were obtained from experiments on opium and on pure narcotine and on mixtures of narcotine and papaverine.

It had been observed, in our search for a general method for the determination of organic bases, that narcotine in the presence of chloroform and aqueous acid solution of ammonium reineckate does not give a precipitate, whereas papaverine does. It was observed that the chloroform layer in that mixture was red-coloured. Subsequent quantitative determinations of mixtures of pure papaverine and narcotine, and opium showed quantitative recoveries of these alkaloids. The recoveries of pure drugs from mixtures are shown in Table 1, and from opium in Table 2. Procedure: A chloroform solution of

Table 1. Recoveries of Narcotine and Papaverine from Mixtures

Narcotine and papaverine used		Narcotine and papaverine recovered	
Amount of narcotine used (mgm.)	Amount of papaverine used (mgm.)	Amount of narcotine recovered (mgm.)	Amount of papaverine recovered (mgm.)
42·4	6·7	42·5	6·75
65·4	9·0	65·2	9·15
79·9	10·8	79·5	10·6
81·10	32·35	81·10	32·6
101·6	25·6	101·0	26·2
174·4	11·65	173·4	11·7

Table 2. Recoveries of Narcotine and Papaverine from Opium

	Anneler's method	New method
Narcotine	58·3 mgm.	63·5 mgm.
Papaverine	28·7 mgm.	29·8 mgm.

papaverine and narcotine was shaken with $N/10$ hydrochloric acid and ammonium reineckate solution (2 per cent) for about ½ hr., using a mechanical shaker. Filtration through a fritted glass filter (medium porosity) yields papaverine reineckate on the filter pad, which is afterwards determined colorimetrically at 525 mμ, and a filtrate containing the narcotine. The red-coloured chloroform from the filtrate is separated from the aqueous layer and shaken with aqueous silver nitrate (1 per cent). The clear chloroform layer is separated and evaporated, yielding colourless crystals of narcotine (even from opium) which are determined by non-aqueous titration using perchloric acid in acetic acid and crystal violet as an indicator.

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Large Periods in Polyethylene: the Origin of Low-Angle X-ray Scattering

MOST crystalline polymers exhibit discontinuous X-ray diffraction effects at small angles indicative of a structural discontinuity of about 100 A., which appears to be a basic feature of these materials[1]. In spite of much research in this field, there is no fully satisfactory explanation of this phenomenon. In our present work an unexpected possibility of interpretation has presented itself.

The linear polyethylene 'Marlex 50' was crystallized by cooling a hot solution in xylene. Plate-like crystals were obtained with habits varying between that of regular lozenges and dendrites[2,3]. The thinnest parts were about 100 A. thick, thickening taking place by a stepwise accretion of new layers of the same thickness resulting in spiral pyramids[2]. The *c*-axes (molecular chains) were found to be perpendicular to the surface of the plates. It was concluded in ref. 2 that the molecules must fold sharply back on themselves to be accommodated in the layers. Accordingly, the thickness of the first layer and that of successive steps would correspond to the distance between successive folds along the molecule. A regular stacking of such layers is expected to give a diffraction effect at small angles. This assumption was tested.

At first a 1 per cent solution of 'Marlex' was crystallized at 68° C. By filtering, a crumbling porous tablet was obtained. The wide-angle X-ray pattern revealed that this material was randomly oriented and fully (or at least very nearly) crystalline. At low angles the pattern consisted of at least four rings which were identified as the first four orders produced by a periodicity of 120 A. These results show: (*a*) We have real Bragg reflexions, a point often debated in the past because of the absence of higher orders in earlier experiments. (*b*) The effect is not produced by an alternation of amorphous and crystalline regions as usually envisaged. (*c*) The magnitude of the periodicity corresponds to that of the thickness of the layers and steps visible under the electron microscope[2].

In another preparation the same polymer was crystallized from a 0·01 per cent solution at 68° C. The crystals were plate-like, similar to Fig. 4 in ref. 2. On slow filtering they formed a compact film. Wide-angle X-ray patterns showed that the film as a whole was oriented, with the *c*-axes perpendicular to the plane of the film. Thus the plane of the crystal plates must be parallel to the film surface. This evidently results from the crystals sedimenting horizontally. The low-angle pattern again revealed a periodicity of 120 A. Once again four orders were distinguishable. These reflexions were in arcs, corresponding to planes parallel to the surface of the film. (This is in close analogy with paraffins.)

In view of this agreement both in magnitude and orientation it can be stated that the discontinuous low-angle scattering effects are produced by the layer structure within the single crystals. The latter is interpreted by us as resulting from the regularity of chain folding[2], and accordingly the low-angle diffraction would record the periodicity of the folding. This implies that the unit cell as usually defined by the chemical repeat period is only a subcell, the real unit cell extending over the full length of the fold.

Strong continuous diffraction was also present within the first discontinuous maximum. In the second type of specimen this had the same direction of orientation as the discontinuous diffraction, but with a still more sharply defined orientation than the latter. This continuous scatter is likely to be due to the individual crystals themselves, the whole stack of layers scattering incoherently. The better orientation is possibly due to the fact that the crystals themselves always lie flat while the top layers within them can be rolled up[2].

Experiments were also carried out on two types of samples which reflect the orientation within the spherulites. One of these was extruded polythylene possessing the 'row structure'[4], the other was nylon 6,6 solidified while flowing out from an extruder[5]. In the first sample the direction perpendicular to the extrusion corresponds to that along the radius of a spherulite[4]; in the nylon sample it is the direction along the extrusion which corresponds to the spherulite radius[5]. In both cases the usual, but strong, discrete low-angle scatter was equatorial with respect to the spherulite radius as identified above. (This same conclusion was reached by Point[6] with another type of specimen.) Thus when single crystals aggregate into spherulites the original layering must become parallel to the radius of the spherulite. This is consistent with the picture of the fibrillar units responsible for spherulite formation being built of curled-up single crystals[2].

In its present form our explanation does not directly account for the discontinuous low-angle X-ray scattering in drawn polymers. As the corresponding spacings are of the same magnitude as in the undrawn samples one would expect the same structural feature to be responsible for it. It is possible that a small proportion of the original crystals turn with their *c*-axes in the draw direction without an unfolding of the chains. (This appears to be supported by the big reduction in the scattering intensity on drawing; unpublished experiments.) Another possibility is that the location of the fold is preserved when the molecules are drawn out in a way which cannot be specified at the moment.

Our thanks are due to Prof. F. C. Frank for many helpful discussions.

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Membrane Currents in Clamped Vertebrate Nerve

Placing nerve membrane in the feed-back arm of an operational amplifier allows one to see what current is needed to make the membrane follow a change in voltage across it. Such a measure, termed 'voltage clamp', has been used for the giant axon of the squid by Hodgkin and Huxley[1]. Their exhaustive study showed several specific non-linear ionic conductances the behaviour of which accounted for the properties of the excited membrane. Whether all irritable tissues show qualitatively the same pattern and use the same ions is yet unknown, since Hodgkin and Huxley's essay has been unique. We have now succeeded in devising voltage clamps for both the node of Ranvier and the cell body.

The first experiments were done with single, isolated motor-nerve fibres of *Rana pipiens* in springtime and at room temperature. These fibres were dissected from sciatic–gastrocnemius preparations following the method described by Tasaki[2] and Stämpfli[3]. The isolated node was laid across a window cut in a 1-mm. (outside diameter) polyethylene tube through which flowed Ringer solution. The tube was separated by air gaps from glass slips on which lay the two adjacent nodes, N_1 and N_3, bathed in artificial intracellular fluid and even cut open to reduce the impedance of the path to the interior of the middle node N_2. External shunts along the internodes were minimized by first bathing the preparation in isotonic sucrose and then playing a gentle air jet on the internodes after the gaps were made. A block diagram of both the mechanical and electrical systems is shown in Fig. 1. Our amplifiers were direct-coupled to the preparation through head stages emitting a current of less than 10^{-14} amp. and showing an impedance to earth better than 10^{14} ohms for direct current, and dropping to 10^9 ohms at 10 kc./s.

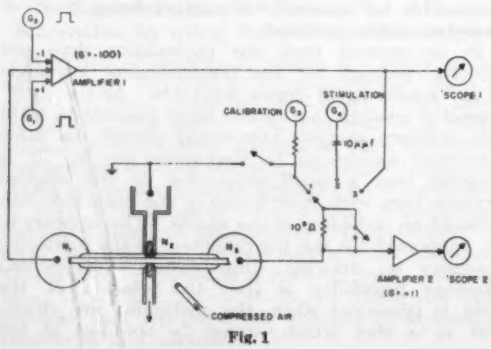

Fig. 1

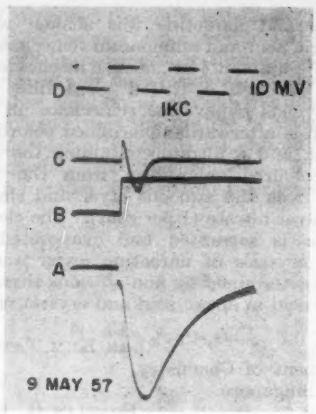

Fig. 2

It seems that the monophasic action potentials which can be recorded from isolated nodes are of two sorts, one showing a smooth fall-away from the peak, the other a marked downward inflexion somewhere in the falling phase. This inflexion can occur sufficiently late to give a trapezoidal appearance to the spike, very like that seen in records from heart muscle. At present, we feel that these two shapes are connected with two different patterns of current flow under the voltage clamp. In the first case (Fig. 2) there is a spike, 2*A*, characterized by a smooth and nearly exponential fall of potential away from the peak. With a sudden depolarization of the magnitude shown in 2*B* (inverted during clamping by the feed-back) we see the current transient, 2*C*. This appears to be a pulse of active inward flow of current which is turned off fairly sharply. The rapid decay of this inward current is to the base-line, indicating that little if any flow is required thereafter to keep the membrane at the new potential. There is not the slightest sign of an active outward current corresponding to the active potassium ion flow in the squid. Such behaviour, true for all levels of depolarization in this

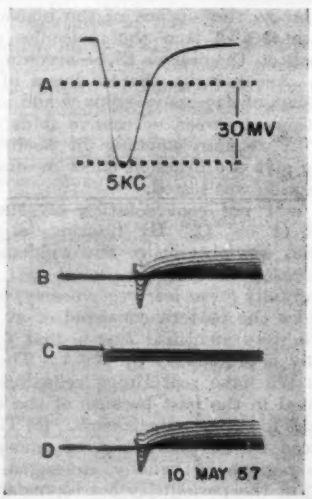

Fig. 3

possibly injured node, holds also for depolarization up to 20 mV. in nodes of the following sort.

In the second case (Fig. 3) the spike, 3*A*, shows a clear doubly inflected decline from the peak. The membrane was clamped to a family of voltage steps, cathodal in 3*B*, anodal in 3*C* and cathodal again in 3*D*. The maximum steps were the same for both polarities. Here, during cathodal clamps at increasing levels of depolarization, all superimposed to show the trend rather than specific quantitative relations, an active initial inward current changes rapidly into an active outward current, and the whole configuration resembles grossly that recorded from the squid axon save for the time-scale. Inward current reversals occur during large enough voltage steps, as is shown in the top record of 3*B*.

These results have been submitted prior to a longer study not only to show the feasibility of a voltage clamp on nodes but also to indicate at least two sorts of behaviour in isolated nodes.

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Paramyosin Elements in Lamellibranch Muscles

In a recent communication[1] it was reported that the ribbon-shaped filaments of paramyosin, isolated from the smooth-muscle fibres of molluscs, closely resemble in their submicroscopic structure the 'crystals' of a tropomyosin which is present in these muscles in very large amounts[2–4]. This implies that paramyosin ribbons contain tropomyosin, that their fine structure is due to their content of this protein, and that 'paramyosin', which until now has been defined only in structural terms[5,6], may in fact be identical with tropomyosin.

These suggestions raise several important questions, one of which concerns the function of the tropomyosins which occur not only in smooth molluscan muscles but also in all the other main types of muscles. In the molluscan muscles, however, one of the tropomyosins is present in exceptionally large quantities. As it happens, very little is known about these muscles. For example, the location of the paramyosin ribbons and the general structure of the muscle fibres have not yet been described; nor is it known where the actomyosin[7] is situated. Clearly such information is needed before one can consider a possible mechanism of contraction. As a beginning we give here a preliminary account of studies on (*a*) the structure of the muscle fibres and (*b*) the location of the water-insoluble tropomyosin. We have used the white parts of the adductor muscles of the following lamellibranch molluscs: *Mytilus edulis*, *Ostrea edulis*, *Gryphaea angulata*, *Pinna nobilis* and *Mercenaria mercenaria*.

Mechanical disintegration of the muscles releases paramyosin elements in the shape of long flat ribbons[5], and at first sight it is difficult to see how these fit into the intact fibre, for it is known[8] that in a transverse section through a muscle all the filaments are approximately circular in shape. But further work on sectioned fibres has now shown that all their filaments have a complex and variable banded structure which can be related to that of the isolated paramyosin ribbons, and that the muscles contain no other elements from which paramyosin ribbons might be derived. Moreover, in accurate transverse sections many of the filaments show a series of regularly spaced parallel lines, and this suggests that they are made up of ribbon-shaped 'sub-filaments' stacked with their surfaces apposed. We conclude that in the intact muscle paramyosin is located in filaments in the fibres, and that all the filaments contain paramyosin.

Between the filaments in the sectioned fibres there is only a relatively small quantity of material, and this does not seem to be arranged in any organized manner. The material has the appearance of irregularly shaped strands which lie approximately parallel to the fibre axis. Existing methods for extracting structural proteins from these muscles remove both actomyosin and tropomyosin[2,7]. Therefore it is not feasible to study the location of either protein by examining extracted muscle fibres. The quantities of these proteins are not accurately known either, but there appears to be more tropomyosin than actomyosin[7]. Thus it is quite possible that actomyosin is located between, rather than within, the filaments. This point cannot be clarified by examination of actomyosin precipitates as these are amorphous[7].

The structural similarity between isolated paramyosin ribbons and 'crystals' of water-insoluble tropomyosin naturally suggests that this protein is located in the filaments; and its quantity[2,7] is too great for all or most of it to lie outside them. Therefore it was surprising to observe in two different types of experiments that isolated paramyosin filaments do not dissolve in hypertonic potassium chloride solutions at neutral *p*H, that is, in solutions which efficiently extract tropomyosin from the muscle[2,7]. The isolated filaments, which are visible in a phase-contrast microscope, do not appear to dissolve when the preparation under the microscope is irrigated with potassium chloride solutions (of any concentration) at *p*H 7·0 or 7·4 (phosphate buffer). Similarly, filaments are still visible in their usual abundance in the residue of a muscle brei which has been extracted several times, or even left overnight in a hypertonic potassium chloride solution. In the electron microscope, banded ribbons with an axial period of 145 A. can still be found. In many of these experiments it was confirmed that normal quantities of protein had been extracted from the brei and that

typical tropomyosin 'crystals' were precipitated from the extract.

These experiments did not exclude the possibility that material is removed from the paramyosin ribbons; the results demonstrate only that the ribbons are not destroyed during the usual procedure for the extraction of tropomyosin.

In other experiments it was found that an alkaline (or acid) potassium chloride solution, for example, Weber's solution (μ 0·7, *p*H 9·1), rapidly and completely dissolves the paramyosin ribbons. After tropomyosin had been extracted thoroughly from the muscle brei at neutral *p*H, a further protein fraction was removed with Weber's solution, and this second fraction was found to be precipitated at about μ 0·15 in the form of needle-shaped 'crystals'. Dr. H. E. Huxley examined these 'crystals' and found that they have the same structure as those of water-insoluble tropomyosin.

All these experiments indicate that some tropomyosin can be left behind in the paramyosin ribbons when the muscle is extracted with neutral hypertonic potassium chloride solutions. The results therefore strengthen our original suggestion that water-insoluble tropomyosin is located in the paramyosin ribbons of lamellibranch smooth muscles. Structural evidence indicates that the ribbons are sub-units of the filaments in the intact fibre. It now remains to be shown if these filaments also contain actomyosin, and if tropomyosin is involved in the contractile mechanism. A full account of the structure of these muscles will be published elsewhere.

One of us (J. L.) acknowledges the financial support of the Nuffield Foundation. We are very grateful to Dr. K. Bailey and Dr. H. E. Huxley for many useful discussions. Dr. Huxley has also helped with electron microscope techniques, and he, together with one of us (J. H.), first observed the fine structure of the filaments in sections of *Mercenaria*.

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An Unsuspected Factor which influences Consumption of Alcohol by Rats

A few years ago a study was made in this Department of the role of alcohol in the production of fatty livers and cirrhosis[1] in rats. The conclusion was drawn that the hepatotoxic effect of long-continued consumption of non-intoxicating amounts of ethanol was negligible under the experimental conditions. Several repetitions and extensions of the work, which we hope to report elsewhere in the near future, have confirmed the conclusion. In the course of attempts to overcome a technical weakness in the earlier study, namely, some uncertainty as to the exact amount of dilute alcohol consumed daily by the rats, a device was developed by one of us that permits accurate measurements of the liquid drunk by the animals. This so-called 'Gillespie drinking fountain', which has now been in use in our rat-colony for about five years, catches any spillage and reduces losses by evaporation to a small known amount (about 300 mgm. or less per day).

Recently, as part of the study, an experiment dealing with self-selection of drinking fluids was undertaken. Measurements were made of the daily consumption of water and dilute alcohol (15 per cent v/v) by 25 rats when offered a choice. Most of the rats drank water almost exclusively. A few, however, seemed to show a marked preference for alcohol. A few rats drank some from each fountain. These observations seemed of interest in view of the nutritional or genotype explanations for alcoholism proposed by Mardones *et al.*[2-4] and by Williams and his colleagues[5,6]. Deficiencies in the ration appeared unlikely to be the cause of the 'alcoholism' of these rats since the diet was as 'complete' as we could make it. Hence a genotype defect, or 'inborn error of metabolism', seemed a possible explanation.

Suddenly, most of the 'alcoholic' rats became 'teetotallers' and some of the others began to consume considerable alcohol. This result was so surprising that it was at first considered probably to be due to an error in recording. When it was repeatedly observed, however, and its reality proved by analysis of the liquids in the fountains, another explanation had to be sought. The mystery was solved when it was noticed that the relative positions of the food-dish, water-fountain and alcohol-fountain controlled, to an astonishing degree, the drinking pattern of some of the rats. The positions of the dispensers were therefore varied deliberately over an 82-day period and the consumption of food, water, alcohol and total calories was noted daily. Only five rats were uninfluenced by the arrangement of the fountains. Thus in the case of 20 rats out of the 25, position of the fountains seemed to affect and in a few cases to control the 'preference'. Two of the rats actually did appear to like alcohol; they drank moderate amounts of it regardless of the arrangement of the fountains. Nine animals seemed rather definitely to prefer water.

The amount of dilute alcohol consumed per day never exceeded 21 ml. and for any one rat did not average more than 7·5 ml. per day. However, with one arrangement an average value as high as 16·7 ml. was attained. The same rat with other arrangements averaged 13·5, 1·7 and 0·6 ml./day, respectively. The amount of energy supplied by alcohol never on any day exceeded 28 per cent of the total calorie intake and usually was less than 20 per cent. The rats never appeared stuporous. The average daily intake of total calories tended to remain relatively constant. When alcohol was consumed the food intake usually fell.

We cannot present a fully satisfactory explanation for the influence of the position of the fountain on the intake of alcohol; but we have noticed two facts that may be significant. Most of the rats lift the automatic-closing lids of the fountains with one paw

and use it to hold the lid up while drinking. Many rats also show a preference for the drinking fountain that is in an uncrowded location.

Possibly our colleagues interested in animal psychology and behaviour might suggest that these observations raise the question of right- or left-pawed preference in rats. Perhaps many of the animals prefer to drink in comfort. The fact remains that neither dietary deficiency nor 'genotype' was concerned in most of the cases of 'alcoholism' observed in the twenty-five rats given a choice of dilute alcohol or tap-water to drink, since the 'disease' was 'cured' by changing the positions of the fountains.

This communication is to provide a warning that the size and shape of cage and the arrangement of self-selection dispensers may exert a strong influence on the apparent 'preference' of rats. Details of the work will be published shortly.

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The Quadratic Relation in Differential Growth

It was shown[1] that the growth in width of the abdomen of the female pea crab, *Pinnotheres pisum*, did not show simple allometry[2], but a continuously variable allometric relation, relative to carapace width. For purely empirical purposes a general polynomial relation was fitted to the two measurements[3], but the quadratic proved a very good 'fit' and it was later pointed out (Reeve, E. C. R., personal communication) that no appreciable improvement was effected by fitting higher powers of the polynomial. It is possible, therefore, that the relation between abdomen-width (y) and carapace-width (x) may be defined, not only adequately but also significantly, by the simple equation $y = a + bx + cx^2$, where a, b, c are constants for any particular abdominal segment, and are parameters for the abdomen as a whole[3].

It seems worth considering possible implications of this relation, should it prove to have more than empirical significance. The second differential of y with respect to x is a constant: $d^2y/dx^2 = 2c$, which implies a constant differential acceleration of growth between the two measurements. At first glance this might seem to have little biological meaning, but supposing that the rate of protein synthesis, and therefore of growth, should be related to the amount of a critical growth-promotor or catalyst present in the cell, for example, possibly pentose nucleic acid[4], then the acceleration of growth should be related to the rate (velocity) of synthesis of this promotor, and therefore a constant differential acceleration of the two measurements could be due to a constant differential pattern of synthesis of pentose nucleic acid in the body. This would apply equally if the two accelerations are negative, as in fact they usually are, in Metazoa; here a constant differential pattern of depletion of pentose nucleic acid, by dilution, exhaustion, etc., is visualized.

Polynomial relations have already been advocated from time to time. A logical merit of such a relation in differential growth is that it could be valid both for y and for the constituent parts of y, unlike the simple allometry relation and many others. Also, the second differential implies that reciprocally it would be equally valid to express x as a quadratic in y. It has been shown further[3,5] that a simple quadratic is technically useful, permitting various integrative algebraical exercises, aimed at defining shape and form as continuous functions of space and time. Other potentialities of the relation need not be considered here. Other examples of continuously variable allometry have been recorded and both these and other examples of differential growth might usefully be tested for a quadratic relation. Where two compared measurements are of different orders of dimension, a more complex relation would be expected and it is important to reduce them to the same dimensional order before testing for the quadratic (or any other) relation.

The limitations and dangers of the mathematical approach to growth are appreciated, but on the other hand no possibly fruitful relation can be neglected. Mathematical approaches have never failed to stimulate interest and further work.

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Production of Sclerotic Granules by *Streptomyces* sp.

Thirumalachar[1] has proposed a new genus *Chainia* of the order Actinomycetales in honour of Prof. E. B. Chain, of the Istituto Superiore Sanità, Rome. The chief distinguishing character of the genus is the formation of sclerotic granules, 16–75μ in diameter, on glucose peptone medium. *C. antibiotica*, the only species described by him, has a branching non-septate mycelium without true aerial mycelium and spores.

Sclerotic granules were observed in a strain of *Streptomyces griseus* isolated from soil at Lethbridge, Alberta, Canada, during my investigations on an anti-fungal antibiotic produced by this organism. These granules developed abundantly on trypticase soy agar (Baltimore Biological Laboratory, Baltimore, Maryland) when the organism was streaked on the plates and incubated at 25° and 37° C. for 36 hr. On this medium no aerial mycelium and spores are produced. In granule formation a hypha thickens and other hyphæ start surrounding it, resulting in the development of a brownish-green mass of sclerotic tissue which eventually becomes black. In the early

stages a hyaline circular sheath can be distinguished around the sclerotic granule but eventually the sheath ruptures and it appears as if the sclerotic mass is surrounded by a sheath of black radiating hyphæ. Some of these sclerotic granules coalesce in pairs, and sometimes in threes, producing a big granule up to 75μ in diameter. The small isolated granules range in diameter from 12 to 45μ.

Sclerotic granules were also produced on trypticase soy agar plates streaked with *S. griseus* strain A.T.C.C. No. 10137 and incubated for 72 hr. at 25° C. The granules in this case were morphologically different from those of the strain isolated from Lethbridge soil as they were more or less circular. No sclerotic granules were produced by *S. antibioticus* A.T.C.C. 8663, *S. lavendulae* A.T.C.C. No. 8664, *S. scabies* St. Catharines No. VI–3*a*–3 obtained from the Bacteriology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario, and *S. venezuelae* obtained from the Prairie Regional Laboratory, Saskatoon, Saskatchewan. Aerial mycelium with spores but without sclerotic granules was produced when the *S. griseus* strain isolated from Lethbridge soil was grown on glucose peptone medium, potato dextrose agar, 'Bacto Tryptone' glucose agar and 'Bacto Sabouraud' maltose agar. On 'Bacto Endo' agar and 'Bacto' nutritive caseinate agar neither aerial mycelium with spores nor sclerotic granules were produced.

When the sclerotic granule-producing strains of *S. griseus* A.T.C.C. No. 10137 and the one isolated from Lethbridge soil were streaked on media containing trypticase and phyton (components of trypticase soy agar) separately no granules were produced. This indicates that, at least with these two strains, both the constituents should be present in the same medium for the production of sclerotic granules.

In the light of these investigations it will be seen that the production of sclerotic granules can occur in strains of *Streptomyces griseus* and that there is no justification for creating the new genus *Chainia* on the basis of the production of these structures.

I am grateful to Dr. M. W. Cormack, officer-in-charge, Plant Pathology Section, Science Service Laboratory, Canada Department of Agriculture, Lethbridge, Alberta, and Dr. W. C. Broadfoot, chief, Science Service Laboratory, Canada Department of Agriculture, Lethbridge, Alberta, for kind suggestions.

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Sarcocystis sp. in the Red-legged Partridge, *Alectoris rufa*, and the Pheasant, *Phasianus colchicus*

A red-legged partridge, *Alectoris rufa*, was sent to this laboratory from Norfolk for post-mortem examination. It was an old cock which had died of a heavy infestation of *Syngamus trachea*, but it was also parasitized with a species of *Sarcocystis*.

The main sites of infection were the superficial pectoral muscles, which were obviously streaky, dehydrated and aerated. The structure of the individual muscle fibres had broken down, and many cysts could be seen under low magnification. They were oval and measured 100–165μ × 60–110μ, with a laminated wall, and contained large numbers of crescent-shaped spores, some of which were degenerating.

Erickson[1] records species of *Sarcocystis* (Sporozoa; Sarcosporidia) from eight orders of birds. The only gallinaceous host is the domestic fowl, from which v. Ratz (1908) recorded *S. horvathi* in Hungary, and Krause and Goronoff (1933) recorded *S. gallinarum* in Bulgaria. Other records from fowls are Kuhn, 1865, and Haines (quoted in Stiles), 1894. Only the first article is available to me here.

A similar infection with cysts of the same size and appearance was seen five years ago in a wild pheasant, also from Norfolk. Once again, the superficial pectoral muscles were affected.

Occasional cases of mallard, infected with *S. rileyi* have been seen, but this would seem to be the first time *A. rufa* and *P. colchicus* have been recorded as hosts.

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Effect of Benzimidazole on Detached Wheat Leaves

Detached wheat leaves when floated on water retain their green colour for a few days only and are usually chlorotic within a week. During a study of the effects of analogues of nucleic acid components on detached wheat leaves we noticed that those that floated on 30–100 p.p.m. of benzimidazole retained their green colour and their capacity to support growth of leaf and stem rusts of wheat for periods up to at least one month. Other compounds reported to be analogues of essential purines and pyrimidines (barbituric acid, 2-amino-4-methyl pyrimidine, 2,6-diamino purine sulphate, thiouracil, 2-chloro-4-methyl benzoic acid at 1–1,000 p.p.m. or azaguanine and azaadenine at 50–100 p.p.m.) did not give this effect. Similarly, there was no effect with the purines, adenine and guanine, and the pyrimidines, thymine, cytosine and uracil at 50–200 p.p.m.

The action of benzimidazole in preventing the destruction of chlorophyll was further investigated. Leaves of *Triticum compactum* (var. Little Club) were detached and floated on 50 p.p.m. benzimidazole and on water. The detached leaves were kept in 6-hr. light periods of 800 foot-candles alternated with 18-hr. dark periods. The temperature was maintained at 20° C. in the light and 13° C. in the dark. Under these conditions microbial development was minimal. Respiration-rates, water-soluble nitrogen and alcohol-insoluble nitrogen were determined at intervals up to 13 days after detachment.

When the colour-value of normal leaves was rated at five and that of leaves devoid of green at zero, the colour of leaves on the benzimidazole solution remained at five for the thirteen days. The colour of the leaves floated on water was estimated at four on the fourth, two to three on the eighth, and one to two on the thirteenth day. The respiration-rate was lower on treated leaves than on those floated on water

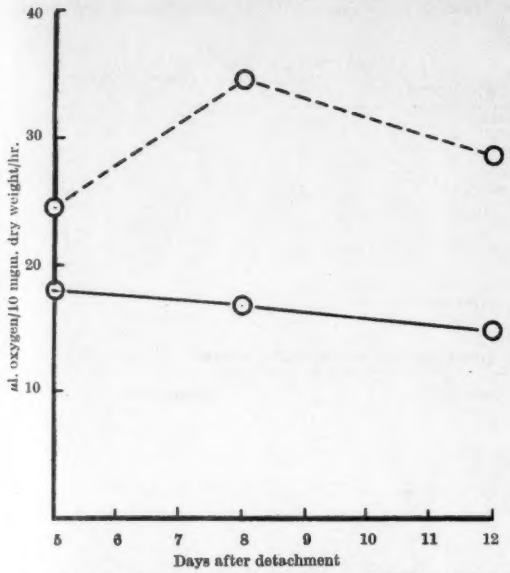

Fig. 1. Oxygen uptake of detached leaves floated on water (broken lines) and on benzimidazole (solid lines)

(Fig. 1). It is seen that the respiratory increase, which normally follows detachment[1], does not occur on benzimidazole. A similar stability in nitrogen metabolism was also observed. Fig. 2 shows that there was little change in the levels of soluble and insoluble nitrogen in the leaves on benzimidazole whereas marked changes occurred in those floated on water. The action of benzimidazole in conserving protein was also indicated by analyses with paper chromatography of the water-soluble extracts used for the nitrogen determinations. Amino-acids, and particularly the amides, were present in much smaller amounts in treated leaves than in leaves floated on water.

While benzimidazole has been shown to act as an antipurine when used on micro-organisms[2,3], there is some evidence that it may also act on other systems,

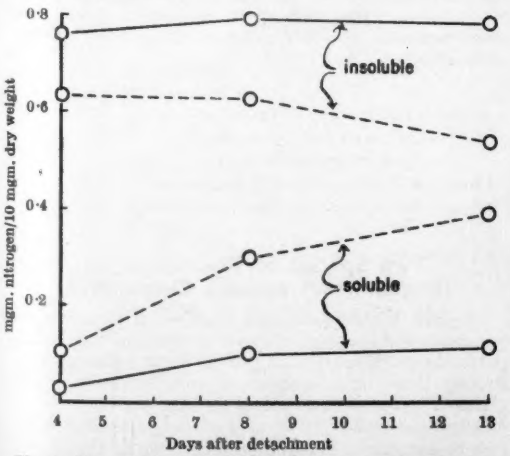

Fig. 2. Changes in soluble and insoluble nitrogen in detached leaves floated on water (broken lines) and on benzimidazole (solid lines)

particularly in higher plants[4,5]. Attempts to reverse the effect of benzimidazole on colour retention by adding normally occurring purine and pyrimidine bases, singly and in combination, were unsuccessful. Chloramphenicol, known to inhibit protein formation in phage-infected bacteria[6], neither reproduced the benzimidazole effect when used alone nor reversed the effect when used in combination with benzimidazole.

In a study of protein metabolism in runner-bean leaves Chibnall[7] found that protein breakdown, normally rapid in detached leaves, was arrested following the development of adventitious roots from the cut petioles; and during the course of this study, Richmond[8] reported that kinetin (6-furfuryl-amino purine) reduced protein loss in detached leaves of *Xanthium*. We have floated detached wheat leaves on 5 p.p.m. of kinetin and found that the effect is similar to that of benzimidazole.

Since so little is known about protein metabolism in detached leaves, it is not possible to state why protein breakdown is arrested by the development of adventitious roots or by the application of these chemicals.

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Variability in Retention of Marine Phytoplankton by Membrane Filters

During a series of experiments designed to determine the relative sizes of tropical pelagic phytoplankton labelled with carbon-14, it was noted that the retentive capacity of '*AA* Millipore' membrane filters varied considerably in three experiments as shown by retention of passed material on a fine filter (Table 1). It seemed surprising that a membrane filter with a pore size of 0·8µ would pass significant amounts of carbon-14 activity, bound in phytoplankton.

Three experiments were performed in the laboratory to determine the retention of *Dunaliella euchlora*, a phytoflagellate grown in sea-water medium, by using membrane filters of different porosities. In each experiment a 40-ml. culture was inoculated with about 10 µc. (0·9 ml.) of $NaH^{14}CO_3$, *p*H 9·7. This was incubated at 22° C. over fluorescent bulbs of 545 foot-candles. The $NaH^{14}CO_3$ was prepared according to the method of Steemann Nielsen[1]. The initial experiment (*A*) was performed with a 25-day-old culture inoculated with carbon-14 twenty-two days before filtration, which may have become bacterized. A 10-ml. aliquot of the algal suspension was removed and filtered through an '*AA* Millipore' filter (pore size, $0·8 \pm 0·05\mu$). (Porosity figures are those supplied by the manufacturers, Millipore Filter Corporation, Watertown, Mass., and Membranfilter, Göttingen.) The filtrate was then drawn through an *HA* (pore size, $0·45 \pm 0·02\mu$) and a *PH* filter (pore size, $0·3 \pm 0·02\mu$). All filter membranes were finally

Table 1. Retention of Pelagic Phytoplankton and *Dunaliella euchlora* labelled with Carbon-14 by Millipore Filters after Serial Filtration

Filter	Experiment 1 November 20, 1956 09° 15·5′ N., 80° 18·0′ W.		Experiment 2 December 2, 1956 05° 09·0′ N., 83° 34′ W.		Experiment 3 December 4, 1956 06° 46·0′ N., 80° 52·0′ W.		*Dunaliella euchlora* Experiment *A*	
	c./m.*	per cent of total	c./m.	per cent of total	c./m.	per cent of total	c./m.	per cent of total
'Millipore *HA*' (Control)	529	—	—	—	117	—	—	—
'Millipore *AA*'	298	55·5	1,464	91·6	71	55·5	123,271	59·6
'Millipore *HA*'	239	44·5	134	8·4	57	44·5	42,054	20·3
'Millipore *PH*'	—	—	—	—	—	—	16,482	8·0
Filtrate	—	—	—	—	—	—	25,115	12·1
Total	537	100	1,598	100	128	100	206,922	100

* c./m. = counts per minute

Table 2. Retention of *D. euchlora* labelled with Carbon-14 by Membrane Filters

Filter	Experiment *B*—July 9, 1957						Experiment *C*—July 18, 1957	
	Series 1		Series 2		Series 3		Series 1	Series 2
	c./m.*	per cent *PH*	c./m.	per cent *PH*	c./m.	per cent *PH*	c./m.	c./m.
'*AA* Millipore'	37,819	79·2	36,846	87·0	33,970	90·0	47,116	45,574
'*HA* Millipore'	46,679	97·7	42,073	99·4	39,915	105·8	46,018	45,662
'*PH* Millipore'	47,744	—	42,326	—	37,721	—	46,176	43,438
Filtrate	0	—	0	—	0	—	—	3,264
					Coarse *MF*†		44,782	45,192
					Medium *MF*		45,982	44,338
					Dense *MF*		42,622	40,270
					Very dense *MF*		33,438	—
					Filtrate		—	4,840

* c./m. = counts per minute; † *MF*, 'Membranfilter'

washed with approximately 75 ml. of *HA*-filtered sea water before drying by suction. The water thus filtered was combined with the original filtrate. The final filtrate was acidified with phosphoric acid to remove uncombined carbon-14, and an aliquot was air-dried for counting on a steel planchet. Each 'Millipore' filter was also air-dried. The activity of the filters and planchets was counted with a Nuclear Measurements Corporation proportional counter (Model *PC*–1). The results are presented in Table 1.

Experiment *B* (Table 2) differed in two respects from experiment *A*. (1) A four-day-old, bacteria-free culture was inoculated with carbon-14 five days before filtration; (2) a 3-ml. aliquot of the radioactive algal suspension was filtered through each of the filters. The filtrates from the *PH* filters were analysed for activity. In experiment *C* (Table 2) an 18-day-old, bacteria-free culture was used and carbon-14 was added two days before filtration of the 3 ml. aliquots. Dry 'Membranfilters' (Göttingen) were also tested to compare their retention of *Dunaliella*. These are rated by the manufacturer as coarse (pore size, 3·0–0·75μ), medium (pore size, 0·75–0·5μ), dense (pore size, 0·5–0·2μ), and very dense (pore size, less than 0·2μ). Filtrates from a dense filter and a *PH* filter were tested for activity.

In Table 1, it can be seen that there may be considerable variability in retention by '*AA* Millipore' filters when used in the field. (Steemann Nielsen[1] found in two experiments that virtually all activity was retained by membrane filters with a pore size slightly in excess of 1μ.) In experiments *A* and *B*, a similar variability in retention of activity exists which seems to be associated with the age of the culture. We believe that this difference in retained activity is largely due to the fragility of the labelled cells. This seems to be borne out by the independent observation of Dr. W. Rohde (personal communication) who, by visual microscopy, noticed that many naked flagellates are destroyed beyond recognition on the surface of membrane filters after filtration. Presumably this is a result of mechanical destruction resulting from filtration. The loss of activity noted with dense and very dense filters may be due to prolonged filtration periods. Such a loss was not found by Steemann Nielsen[1].

Except in the last experiment, a significant portion of the algal-bound activity passed through the *AA* filters. In the case of the *Dunaliella* experiments, the cell-size ranged from 6 to 8μ and there was no evidence of cell debris in the culture medium prior to filtration. From these experiments it is concluded that it is advisable to employ filters with a porosity of at least 0·45μ and with relatively rapid flow characteristics, when sampling phytoplankton labelled with carbon-14.

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Two Species of *Trachelomonas* (Euglenineae) without Chlorophyll

In 1883 Klebs[1] published a paper of fundamental importance describing a great number of flagellates, particularly Euglenineae, and their relationships. Among these organisms there were members of the genus *Trachelomonas* which is characterized by a *Euglena*-like cell-body in an envelope encrusted with iron and manganese compounds[2]. Two of the species Klebs observed are of special interest because, in contrast with the multitude of species of this genus,

they were devoid of chromatophores, have consequently no photosynthetical pigments and must have been heterotrophic.

Colourless forms are not rare in the Euglenineae[3,4]; but members of *Trachelomonas* have not generally a tendency to utilize organic nutrients. Chlorophyll-free species appear therefore to have a kind of nutrition different from the majority, and it is difficult to imagine how they can have survived the loss of their chromatophores.

Although Klebs found at least one of the colourless species of *Trachelomonas* to be not at all rare in infusions of algae, these species have scarcely been observed since. Deflandre[5] in his monograph records only one instance of the occurrence of permanently colourless trachelomonads.

I have recently found in mud gathered from a road puddle two chlorophyll-free species of *Trachelomonas* which are identical with, or very near, those observed by Klebs. One that was seen soon after the material had been brought in disappeared after a few days. Three weeks later, however, when the putrefaction caused by a boiled pea I had added to supply organic substances had diminished, and green Euglenaceae had appeared, the two colourless species of *Trachelomonas* were found in considerable numbers, first one and then the other.

These heterotrophic forms have evidently narrow ecological ranges. After a few days they disappeared again. Both are very motile, possess eye-spots and are negatively phototactic. That which appeared first has an envelope like that of the green species *T. volvocina*. It may be identical with Klebs's *T. volvocina* var. *hyalina*. The other one is no doubt Klebs's *T. reticulata* and has an ovoid reddish-brown envelope characterized by neat delicate ornamentation.

The peculiarities of the habitat in which these organisms live are difficult to define; only by growing them under controlled conditions would it be possible to understand them better; but such cultures have not been accomplished. Obviously a certain degree of putrefaction is relevant, but the two species are now identical in their ecological requirements. It is nevertheless remarkable that the only two colourless trachelomonads known were found in the same place, and together with several species of green Euglenaceae. These thrive where organic substances are broken down by bacteria, and the availability of iron and manganese reduced to the lower oxidation state and kept in solution by complex formation is probably the main factor, along with a high carbon dioxide content. This appears to be similar in the colourless forms for which, however, organic nutrients play a greater part. In no case have the conditions as yet been established in which iron- and manganese-deposits are formed by 'iron organisms', neither with flagellates[6] nor with bacteria[7]. In the case of the colourless species of *Trachelomonas* this would be of special interest.

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Fractionation of Isolated Lucerne and other Triterpenoidal Saponins

THE constituent saponins of bulk triterpenoidal saponins of lucerne and certain other plant materials did not separate satisfactorily on paper chromatograms with various solvents used for other saponins[1]. It has been found that modified solvent systems or multiple development give the most promising results[2]. Ascending paper chromatography was more convenient; long running times with descending paper chromatography produced streaking with many saponins. Horizontal paper electrophoresis with weak borate buffer was also used successfully.

Ascending paper chromatography using *n*-butanol/ethanol/*p*H 9 borate buffer (1/1/1), ethyl acetate/glacial acetic acid/water[3] (11/2/2) and ethyl acetate/glacial acetic acid/water (13/3/3) were employed. Whatman No. 4 paper was impregnated with *p*H 9 borate buffer for the first solvent and *M*/5 potassium hydrogen phosphate solution for the second solvent and the papers dried in air before use. With ethyl acetate solvents multiple development was employed (five times).

Lucerne (*Medicago sativa* L.) bulk saponin, isolated by the cholesterol method[4], appears to consist of four constituents separable by paper electrophoresis using borate buffer (sodium tetraborate 9·54 gm./l.), probably seven separable by paper chromatography using *n*-butanol/ethanol/*p*H 9 borate buffer solvent and seven by paper chromatography using ethyl acetate/glacial acetic acid/water solvent. Various lucerne saponin fractions prepared by the recommended[4] ethanol–ether precipitation procedure were examined before and after deionization with 'Zeo-Karb 225' and 'De-Acidite *E*'. There was no apparent difference in saponin constituents between these fractions and the bulk saponin. It would thus seem that these precipitation procedures fail to bring about any fractionation.

Bulk triterpenoidal wood saponins from *Castanospermum australe* R. Br. (wood), *Emmenospermum alphitinioides* F. Muell. (wood), and *Sideroxylon pohlmanianum* F. Muell. (bark); mora (*Mora excelsa*), morabukea (*M. gonggripii*) and makoré (*Mimusops heckelii*); commercial saponin (B.D.H., Ltd.) from bark (*Quillaja saponaria* Molina) and commercial saponin white (B.D.H., Ltd.); Mexican cactus bulk saponins (triterpenoidal) from *Lemairocereus beneckei* Ehrenberg, *L. longispinus* sp. nov., *L. stellatus* Pfeiffer and *L. thurberi* Engelmann, as well as pure echinocystic acid glycoside, were examined. All bulk saponins examined proved to be mixtures of closely related substances; some were of appreciable complexity. Echinocystic acid glycoside behaved as a single substance.

Some bulk saponins behaved as single substances during paper electrophoresis, but proved to be inhomogeneous when examined by paper chromatography using the ethyl acetate/glacial acetic acid/water solvent (for example, mora group saponins). Another, when examined by paper electrophoresis, proved to be a mixture, although paper chromatography with the ethyl acetate/glacial acetic acid/water solvent failed to resolve this mixture (*Castanospermum* bulk saponin). One explanation could be that paper electrophoresis with aqueous borate buffer may indicate the number of different oligosaccharide species attached to the sapogenin, while separation achieved by paper chromatography with non-borate

containing organic solvents may be due more to the differences in the sapogenin portion than in the oligosaccharide.

The nutritional effects of triterpenoidal bulk saponins[3], and especially the pronounced physiological effects that can be produced in the ruminant by bulk lucerne saponin[5], stress the need for the isolation of purified constituent saponins from lucerne, and other herbage plants, to facilitate further studies of these effects and, in particular, their role in bloat, since bloat causes considerable losses in animal production in the Commonwealth and elsewhere[6].

I wish to thank Prof. C. Djerassi, and Drs. R. Laidlaw, J. H. Simes and C. R. Thompson for generous gifts of saponins as well as Dr. I. Belič for a pure sample of echinocystic acid glycoside. I am grateful to the Agricultural Research Council for support.

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Antitumour Effect of Culture Media from Tumour-immune Spleens

The antigenic activity of tumours has been indicated by several authors using immunological or other *in vitro* methods, and also passive transfer of antitumour agents by serum injections from animals with regressed tumours[1–4].

In the experiments reported here, fragments of spleens of rats (black Walker-resistant strain, eleventh generation of brother–sister mating) were cultivated in roller tubes on glass, one whole spleen in ten 16 mm. × 160 mm. tubes with 4 ml. 50 per cent horse serum–Tyrode medium in each. Abundant outgrowth of amoeboid, giant and fibroblast-like cells was noted. The medium was collected three times a week during three weeks. Spleens were taken either from normal rats, or from rats hyperimmunized by repeated implantations of the Walker 256 tumour; this regresses in resistant rats at first implantation and does not take at further implants.

The medium was collected and thoroughly centrifuged to remove any cells released from the cultures, and then injected without storage on the days of collection in ten doses of about 5 ml. intraperitoneally. The recipients were Wistar rats implanted intramuscularly on the day of the first culture medium injection with Walker 256 tumour-cell suspension. The suspension was prepared overnight by means of an electromagnetic stirrer from tumour fragments at 4° C. in phosphate-buffered saline. In each experimental set every rat was implanted with an equal dose of live tumour cells (estimated by the method of unstained cells count[8]). The doses were about 6 million cells per rat in the first experiment, 1 million in the second, and 8 million in the third.

Table 1

Treatment: culture medium from		No. of rats with tumours	Deaths up to 42 days after tumour implantation		Range of survival (days)	No. of regressions after treatment
				(Per cent)		
I	Normal spleens	5	5/5	100	19–36	0
	Immune spleens	7	4/7	57	28–46	0
II	Normal spleens	8	6/8	75	24–75	0
	Immune spleens	7	2/7	29	37–73	2
III	Normal spleens	9	8/9	89	19–46	0
	Immune spleens	9		44	25–47	3
Total	Normal spleens	22	4/9 19/22	86	19–75	0
	Immune spleens	23	10/23	43	25–73	5

The results of three independent experiments are summarized in Table 1.

Our experience has shown that, as a rule, six weeks is the life-span of susceptible rats implanted with the tumour used. For this reason the number of deaths up to the 42nd day was chosen as a standard for the influence of the treatment. The rats used in these experiments are commercial Wistar, not inbred for the susceptibility to Walker 256 tumour; some individuals from this source can live with the implanted tumour considerably longer without any treatment. Even typically resistant individuals can be selected from this strain, the immune serum of which inhibits the growth of the tumour if injected to tumour-bearing rats (unpublished results). We conclude that the animals in our experiments, which are capable of relatively high spontaneous defence, are those which were cured by the addition of active principle from immune spleens cultivated *in vitro*.

The production of antibodies against bacterial and protein antigens in cultures of immune spleens has been repeatedly demonstrated[6,7]. This was not done, within our knowledge, with tumour antigens, though an inhibition of tumour explants grown together with immune spleen was observed[8].

These results show that passively transmissible antitumour factors are present in a culture medium of tumour-immune spleens. It is not decided here whether the active substance(s) are produced in the cultures as a continuation of the process initiated *in vivo*, or simply extracted from the cultivated spleen fragments. Elucidation of this, the isolation of the active principle, and a trial of active immunization of spleen cells *in vitro* against tumour antigens are being investigated.

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[1] Zilber, L. A., *J. Nat. Canc. Inst.*, **18**, 341 (1957).

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Development of Multiple Cysts and of Hæmorrhagic Affections of Internal Organs in Albino Rats treated during the Embryonic or New-born Period with Rous Sarcoma Virus

In contrast to other malignant animal tumours, such as the Ehrlich adenocarcinoma of mice, the Croker mice sarcoma or the Brown–Pierce rabbit epithelioma, which could be transplanted to the embryos of white rats in serial passages[1], the tissue of the Rous chick sarcoma could only exceptionally be grown under such conditions. However, in many rats grown from embryos inoculated with minced tissue of the Rous sarcoma we have detected[2] multiple cysts. The observations recorded here reveal that white rats are highly susceptible to the Rous sarcoma virus administered both during embryonic life and the first two days of postnatal life.

A thoroughly minced dense suspension (about 50 per cent) of the Rous sarcoma of a young chick was injected under the skin of the back of each embryo of a laparatomized pregnant white rat, 5–1 day prior to birth in a dose of 0·1–0·25 ml.

6–45 days after inoculation, and eventually at a later date, multiple cysts develop in rats originating from the inoculated embryos, in the cervical region and/or in the region of the groin and axillary lymphatic nodes, eventually in other places as well. Usually the cysts appear in 2–3 week old rats. Such multiple cysts have developed in 74 out of 123 rats originating from embryos inoculated with the Rous sarcoma, that is to say in more than 50 per cent[3] (Figs. 1, *A*, *B* and *C*).

These are thin-walled cysts filled with a fluid which contains about 20,000,000 lymphocytes and about 4,000,000 macrophages per ml. At more advanced stages of development the erythrocyte number in the fluid is appreciably increased. The cysts grow in size more or less rapidly, eventually up to 7–10 or even 20 ml. capacity, resulting in death of the rats. The total nitrogen content of the cell-free cyst fluid averaged 450 mgm. per cent and protein nitrogen 320 mgm. per cent. The wall of the cyst consists of rat fibroblasts and of a small amount of collagen fibres. It is infiltrated somewhat with lymphocytes while eventually large numbers of mast cells may appear. Horse serum protein administered to the cyst-affected rats is readily revealed in the cyst fluid through precipitation with the anti-horse rabbit serum.

Susceptibility of the rat embryos to the virus of the Rous sarcoma decreases with age. The administration of the suspension of the Rous sarcoma to newborn rats either subcutaneously or intraperitoneally, within the first 48 hr. of life, likewise results in the development of multiple cysts, but they appear late and in a smaller percentage of cases than after administration to the embryos.

In some rats inoculated with Rous sarcoma both during the embryonic and new-born period there develop, at various periods following inoculation (sometimes late), vesicular-hæmorrhagic affections of the lungs with a hæmorrhagic exudate in the pleural cavity, and eventually hepatic affections with a pronounced jaundice. These affections are less frequent than the cysts. Sometimes they are combined with the latter and eventually appear in rats with no cysts at all.

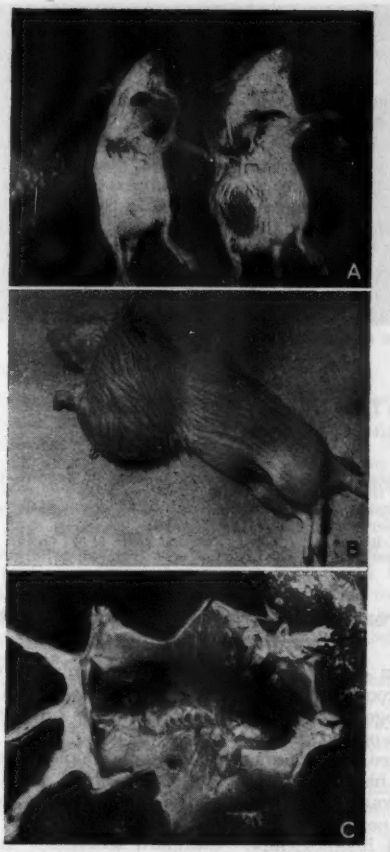

Fig. 1. *A*, Multiple cysts in the cervical region and in the region of the groin and axillary lymphatic nodes in 21-day old rats, inoculated during the embryonic life. *B*, Large cysts of the cervical and axillary region of a 30-day old rat. The cyst appeared on the fifteenth day of life. *C*, A dissection of the cyst of the cervical region

The virus of the Rous sarcoma is present in the cyst membrane: inoculation of the minced membrane of the cyst to chicks resulted in development of a typical Rous sarcoma 31–40 days after the inoculation.

No cysts develop at the site of injection of the suspension of the Rous sarcoma to embryos or newborn rats. Moreover, in those single cases where they do develop at the site of injection heterotransplants of the chick Rous sarcoma multiple cysts appear after resorption of the transplant.

In no case did we note any cysts or affection of the internal organs after injection of rat embryos with suspensions of normal tissues of the chick, rabbit or man, nor of other malignant tumours (Crocker's sarcoma, Ehrlich's adenocarcinoma or Brown–Pierce epithelioma). All the experiments were carried out on rats of the same batch free of spontaneous neoplasms.

All these facts show that the pathological processes at issue are caused by the virus of the Rous sarcoma.

Cyst formation in rats as caused by the above virus changes suggests a comparatively restricted

specialization and peculiarity of pathogenic action of these tumour-inciting viruses.

The foregoing results might presumably be related to the hæmorrhagic disease as caused by the Rous sarcoma in chick embryos[3] being associated with vascular affections.

It is likewise possible that the mechanism of cyst formation approaches to a certain extent normal morphogenetic processes in animals. The morphogenetic correlations of the terminating period of embryonic development may keep under a certain control the cells reproducing under the influence of the virus of the Rous sarcoma, and this may be one of the causes of cyst development. The question is thus raised as to the possible role of viruses in the genesis of some kinds of cysts in humans.

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Treatment of Cancer in Dogs by Intravenous Methylene Blue

The appearance of a report by Holman[1] on the apparently destructive effect of orally administered hydrogen peroxide on rat tumours has prompted me to set on record my own experiences.

Since 1941 numerous cases of neoplasia in dogs have been brought to my small-animal clinic, often in advanced stages of the disease. Generally, biopsies were performed and the nature of the tumour established histologically. Standard treatment involved the intravenous administration of a 2 per cent aqueous solution of methylene blue in doses of 2–10 c.c., repeated on alternate days or at weekly intervals. When practicable, the whole or greater part of the primary growth was removed surgically.

Methylene blue treatment appeared to be without effect on the slowly growing tumours and on carcinomas, but gave encouraging results in the rapidly growing sarcomas, particularly where most of the primary growth could be removed. In such cases the use of the dye was followed by necrosis and sloughing of remaining tumour tissue and complete healing of the wound. A number of cases are in good health and have survived without apparent recurrence of the tumour for up to five years, although at the time of treatment the growth was doubling itself in size every fortnight. Thus, there is evidence that early metastatic conditions may be successfully treated, but where internal organs are extensively affected, dye administration is prone to produce an acute toxæmic state.

There seems to be no doubt that the intravenous use of methylene blue can be a most valuable adjunct to surgery in the destruction of primary sarcomatous growths, and perhaps also of early secondary growths, but the mechanism of its action can only be surmised. In the light of Holman's observations it seems possible that methylene blue, which can function as a hydrogen acceptor, may interfere with the catalase–hydrogen peroxide system and that tumour cells are more sensitive to this kind of metabolic disturbance than normal tissue cells. I do not, of course, claim that methylene blue is necessarily the most effective agent for achieving this effect, but hope that my experience may have helped to identify a weak link in the metabolic processes of the tumour cell and may arouse the interest of investigators better equipped to attack this problem.

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Attempted Control of Ectromelia in a Mouse-breeding Colony

A review of intercurrent ectromelia infection in mouse colonies in Great Britain has been made by Tuffery[1]. During April 1955 a virulent form of the disease became manifest among all three main strains, *R* III, *A* and *CBA*, bred in this laboratory. The establishment and growth of transplantable tumours *in vivo* and *in vitro* concurrently deteriorated, and a connexion with the outbreak of the disease was suspected. In consequence, a programme of vaccination with calf lymph was instituted, as suggested by Lane-Petter[2]. This communication records the results of this procedure carried out over a period of two years.

A satisfactory technique was scarification of a small region on the dorsal surface of the tail with a sterile scalpel dipped in calf-lymph vaccine—diluted five times with McIlvaine's citric acid phosphate buffer at *p*H 7·0 at a concentration of one part to forty-six of distilled water. The vaccinated mice were checked after six days for the typical scab and swelling denoting a positive reactor to the vaccinia virus.

Initially all mice in the colony were vaccinated, but owing to the demands of experimental programmes it was not possible to cull all negative reactors. Breeding mice were replaced as soon as possible by positive reactors and all negative reactors were culled when a sufficient number of positive reactors became available for experimental purposes. All five-week-old mice have now been vaccinated for a period of two years. Fig. 1 illustrates the average monthly

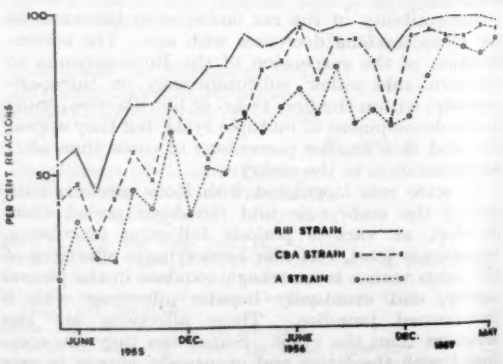

Fig. 1

proportions of reactors in the three strains over this period. The numbers vaccinated weekly were 200–350 in the *R* III strain and 30–60 in the *CBA* and *A* strains. The incidence of the disease prior to vaccination showed a correlation with the initial proportions of reactors in the three strains. The establishment and growth, *in vivo* and *in vitro*, of the transplantable tumours maintained in these strains improved considerably soon after the commencement of vaccination.

The results of this extended programme of vaccination suggest that the control of ectromelia can be accomplished in a breeding colony by this technique. It is suggested that once the proportions of reactors approximate 100 per cent, vaccination of breeders only should be necessary to maintain a high degree of control.

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A Technique for obtaining Clone Cultures of Soil Amœbæ in Sterile Liquid Medium

On previous occasions free-living and parasitic amœbæ have been obtained free from their associated bacteria by sterilization of the cysts either by washing in bactericidal chemicals[1,2] or in antibiotics[3,4]. The technique I have used for isolating clones of soil amœbæ and growing them in sterile peptone solution involves the treatment of the trophozoite stage with antibiotics, making use of the fact that the amœbæ are more tolerant to many antibiotics than are certain bacteria.

The complete isolation procedure was as follows: A soil sample taken from 1–2 in. below the surface was mixed with distilled water and, after allowing the larger debris to settle out for 2–3 min., the supernatant was poured in a thin film on to a nutrient agar plate. Nutrient agar for this and subsequent platings was made up of 1·5 per cent agar and 0·5 per cent peptone in distilled water. After incubating the soil-washing plate for 10–12 days at 27° C. many cysts of 10–20μ in diameter could be seen together with bacteria, fungal hyphæ and debris.

The contents of this plate were then washed into a centrifuge tube and the cysts largely freed from bacteria and hyphæ by repeated centrifugation and resuspension in sterile distilled water.

A drop of water containing cysts was placed on a slide and single cysts selected and removed with the aid of a Zeiss micromanipulator. A ×10 eyepiece and a ×10 objective were found to be the most convenient for the manipulator microscope. Each cyst was transferred to the centre of an *Aerobacter aerogenes* streak on a nutrient agar plate. *Aerobacter* was selected because it is non-motile and is a good food source for soil amœbæ[3]. Thirty such transfers were made and after incubating them at 27° C. for

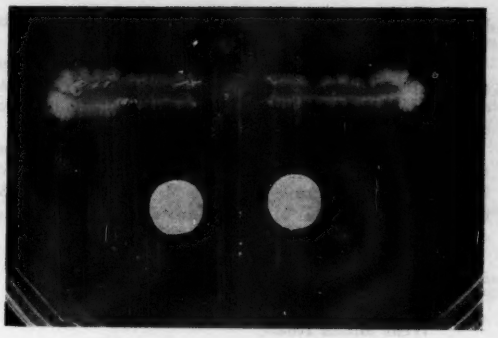

Fig. 1

10–15 days twenty-one of them had formed large colonies of amœbæ.

Upon examining these cultures it could be seen that many trophozoites had migrated out on to the agar and many of these were found to carry a small clump of bacteria at their 'posterior' end. It appeared that any bacteria from the original cyst washing which were transferred in the pipette along with a cyst had been diluted out and suppressed by the *Aerobacter*. Accordingly, antibiotics having the maximum effect on *Aerobacter* were selected. Streptomycin, terramycin and erythromycin gave satisfactory results.

A sterile wire loop was then used for transferring some of the amœbæ from the outlying area on to a second *Aerobacter* streak prepared as before. This plate was incubated at 27° C. until the amœbæ had begun to move on to the surrounding agar, usually after 2–3 days, at which point filter-paper disks ¼ in. in diameter and containing 10 μgm. of an antibiotic were placed approximately ½ in. apart and ½ in. from the streak (Fig. 1). Two disks containing different antibiotics were placed on each plate.

After incubation of these plates for a further 24 hr. a ring of amœbæ could be seen around and at a little distance from the disk at what was presumably the region of the antibiotic gradient corresponding to their maximum tolerance. Two days later the amœbæ could be seen close to the disks.

A small piece of agar from the region between the disks was then cut out with a sterile wire loop and transferred to a McCartney bottle containing sterile 4 per cent peptone solution. After incubation for 20 days, eleven out of the twenty bottles used were found to contain dense cultures of amœbæ. Various kinds of peptone have been used in liquid media, of which the most satisfactory was 'Oxoid' mycological peptone at a 4 per cent concentration in distilled water. Although the addition of autoclaved *Aerobacter* to the peptone solution increased the growth-rate appreciably it was not essential for growth in any of the clones isolated. It was also found unnecessary to add antibiotics to the medium. Growth was considerably inhibited when penicillin (200 units per ml.) and streptomycin (1,000 units per ml.) were added.

The most convenient vessels for maintaining cultures are wide-mouthed McCartney bottles, which, with 10 ml. of solution, will support a culture density of $4–8 \times 10^5$ amœbæ per ml.

Standard sterility tests have been carried out and the results indicate a truly axenic culture. The

procedure has been repeated on subsequent occasions with similar results.

A preliminary investigation has indicated that most of the clones belong to the genus *Hartmanella*[5], and a fuller inquiry, together with the isolation of clones from different habitats, is being carried out.

I wish to thank Dr. J. C. Gould, of the Bacteriology Department, University of Edinburgh, for his advice concerning antibiotics, and Prof. M. M. Swann and Mrs. K. M. G. Adam for their help and discussion.

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[1] Dobell, C., *Ann. Soc. Belg. Trop. Med.*, 201 (1941).
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Ultra-thin Serial Sectioning with Rocking Microtomes

A well-known difficulty in using rocking microtomes for ultra-thin sectioning is the tendency for the cut section to be picked up on the return stroke. A number of mechanical devices have been described[1] which attempt to overcome this. The device described here is a non-mechanical and exceedingly simple but effective aid to serial sectioning.

A No. 1 hypodermic needle is cut off a quarter of an inch or so from the hilt and bent to hook over and into the trough attached to the cutting knife. The hilt is provided with a rubber teat and reconnected to the hook with a suitable 'Polythene' or other tube. The whole is then filled with the liquid normally used in the trough, say, 10 per cent acetone, and the hook suspended on the trough edge, the tip inside. The trough is then filled with liquid to just below the knife edge, a level normally inadequate for sectioning. The level can now be brought to the optimum for section cutting by pressing on the teat for the cutting stroke of the microtome, while by releasing the teat the liquid level can be reduced to prevent the section being picked up on the upward stroke.

Incidental points in the construction are the *S*-bend made in the 'Polythene' tube to improve its accommodation to the various positions of the knife, which would be unnecessary if a more flexible rubber tube were used, and a clamp attached to the knife-holder to keep the tube in position.

Uniform serial sections, showing the silver or gold interference colours associated with the thinnest sections, can be cut without great difficulty from blocks with the relatively large surface area of 1 mm. × 0·5 mm., while smaller blocks can be cut serially *ad lib.* and with ease.

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Response of the Ceric–Cerous System at High Dose-Levels of Cobalt-60 γ-Rays

The radiation yield value of cerous ion in the irradiation of ceric solutions has recently been given as 2·45 ± 0·08 for cobalt-60 γ-rays[1]. This is somewhat lower than figures which have formerly been accepted. In a recent determination of the value of $G(Ce^{3+})$ at high dose-levels, I have obtained a result which confirms the lower value. This value of $G(Ce^{3+}) = 2{\cdot}36 \pm 0{\cdot}12$ molecules/100 eV. was obtained by working in the dose-range 0·1–1 megarads at a dose-rate of $1{\cdot}4 \times 10^5$ rads/hr.

The ceric ammonium sulphate solution used was made up in triply distilled water to a strength of 4,000 μmoles/l. in cerium, the solution being made 0·8 *N* in sulphuric acid ('Analar'). The water used was distilled twice over alkaline potassium permanganate. The ceric ammonium sulphate was used without further purification, and as supplied by G. F. Smith Chemical Co., Columbus, Ohio.

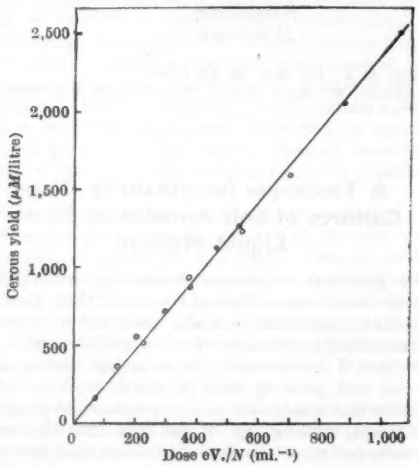

Fig. 1

The solution was irradiated in a four-kilocurie cobalt-60 source in 15-ml. bottles placed in standardized positions. Dose-rates were measured in the standard positions by filling the same bottles with ferrous sulphate solution, and measuring spectrophotometrically the concentration of ferric ion produced. A $G(Fe^{3+})$ value of 15·6 was assumed. In this way, errors due to attenuation in the 15-ml. bottles were avoided. Analysis was carried out by potentiometric titration with ferrous ammonium sulphate solution in 0·8 *N* sulphuric acid. 5-ml. samples were titrated using a Willard–Baldyreff electrode system[2], each titration being duplicated.

The graph shows that within the limits of error the response of the ceric/cerous system is linear up to one megarad eV./*N* (ml.$^{-1}$).

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Oct. 22.

[1] Johnson and Weiss, *Proc. Roy. Soc.*, A, **240**, 189 (1957).
[2] Scott, Scientific Report No. 3, Dugway Proving Ground, U.S.A. (Jan. 1956).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 9

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Where Should Research End and Development Start?" opened by Dr. K. J. R. Wilkinson.

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 15 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. H. Batzer: "Experiments on, and Theory of, Formation of Fibres".

Tuesday, December 10

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. K. E. Clare, Mr. M. J. Tomlinson, Mr. I. K. Nixon and Mr. B. O. Skipp: Symposium on "Airfield Construction on Overseas Soils".

INSTITUTION OF MECHANICAL ENGINEERS, AUTOMOBILE DIVISION (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Air or Water Cooling?"

Wednesday, December 11

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. H. Harris: "Biochemical Genetics".*

PHYSICAL SOCIETY, COLOUR GROUP (in the Physics Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3.30 p.m.—Mr. L. C. Jesty: "Report on the Meeting on Colour Television, Paris, 1957"; Dr. W. S. Stiles, F.R.S.: "Report on the Symposium on Visual Problems of Colour, Teddington, 1957"; Prof. W. D. Wright: "Report on the C.I.E. Working Party on Colorimetry, Teddington, 1957".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. W. B. Harland: "The Caledonian Sequence in Ny Friesland, Spitsbergen".

BUCKLAND FOUNDATION (at the Sir John Cass College, Jewry Street, Aldgate, London, E.C.3), at 5.30 p.m.—Dr. A. P. Orr: "The Fertile Sea—From Plankton to Fish".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. S. Weiner: "The Settlement of Europeans in Extreme Climates".*

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. H. E. Holman, Mr. G. C. Newton and Mr. S. F. Quinn: "A Flying-Spot Film Scanner for Television".

BRITISH GLACIOLOGICAL SOCIETY (at Bedford College, Regent's Park, London, N.W.1), at 6 p.m.—Annual General Meeting. Mr. G. Manley: "Snow, Glaciers and Climate".

INSTITUTE OF PHYSICS, LONDON AND HOME COUNTIES BRANCH (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. B. H. Briggs: "Irregularities and Movements in the Ionosphere".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Second Meeting on "Some Nutritional and Allied Problems Confronting the Food Manufacturer". Dr. C. H. Lea: "Technological Aspects of Antioxidants"; Mr. R. J. Ward: "Biochemical and Pharmacological Aspects of Antioxidants".

INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Reclamation of Lubricants".

INSTITUTE OF METALS, LONDON LOCAL SECTION (joint meeting with the LONDON BRANCH of the INSTITUTE OF BRITISH FOUNDRYMEN, at the Constitutional Club, Northumberland Avenue, London, W.C.2), at 7.30 p.m.—Mr. F. Hudson: "Properties of Castings".

RADAR ASSOCIATION (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Mr. L. D. Bedford: "Some Aspects of Guided Missiles".

Wednesday, December 11—Thursday, December 12

IRON AND STEEL INSTITUTE, IRON AND STEEL ENGINEERS GROUP (at Church House, Westminster, London, S.W.1)—Meeting on "Water Pollution in the Iron and Steel Industry".

Thursday, December 12

ROYAL INSTITUTION, LIBRARY CIRCLE (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. K. D. C. Vernon: "The Re-organization of the R.I. Library".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Northern Polytechnic, St. John Street, London, E.C.1), at 7 p.m.—Mr. A. R. Powell, F.R.S.: "Recent Advances in the Chemistry and Technology of the Rare Earth Metals".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. J. F. B. Edeson: "The Experimental Transmission of *Wuchereria malayi* from Man to Various Animals in Malaya".

Friday, December 13

BIOCHEMICAL SOCIETY (at the Institute of Basic Medical Sciences, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2), at 11.30 a.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Basic Experiments on Servo Mechanisms", opened by Mr. W. Chellingsworth.

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. Ing. Hans Thoma: "High Pressure Hydraulic Transmission" (James Clayton Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. King: "A Debt to Defects".

Friday, December 13—Saturday, December 14

BRITISH PSYCHOLOGICAL SOCIETY (at University College, Gower Street, London, W.C.1)—Conference.

Saturday, December 14

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Douglas Botting: "Socotra: The Island of Dragon's Blood".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

HEAD (graduate of a British university with appropriate teaching, industrial and research experience) OF THE DEPARTMENT OF SCIENCE AND METALLURGY, Constantine Technical College, Middlesbrough—The Director of Education, Woodlands Road, Middlesbrough (December 14).

LECTURER TO TEACH SCIENCE SUBJECTS, INCLUDING APPLIED SCIENCE AND NUTRITION—The Principal, College of Bakery, Catering, Domestic Science and Associated Studies, Bridge Street, Birmingham 1 (December 14).

READER (with high academic qualifications and special experience of analytical techniques) IN ANALYTICAL CHEMISTRY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (December 14).

SCIENTIST (graduate with a biochemical background), for work mainly on amino-acid tolerance tests—The Secretary, Institute of Neurology, Queen Square, London, W.C.1 (December 14).

TEACHER, Grade B (with an honours degree and able to take the subject to degree standard), IN MATHEMATICS—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1 (December 16).

UNIVERSITY DEMONSTRATOR (with an honours degree or post-graduate qualification in an appropriate subject, and preferably some teaching experience) IN AGRICULTURAL ENTOMOLOGY—The Secretary, School of Agriculture, The University, Downing Street, Cambridge (December 20).

ASSISTANT IN THE DEPARTMENT OF ZOOLOGY—The Secretary, The University, Edinburgh (December 28).

SENIOR LECTURER (with a good honours degree, teaching experience, and wide industrial experience related to instrument engineering and/or electronics) IN PHYSICS—The Registrar, Flintshire Technical College, Connah's Quay, near Chester (December 31).

LECTURER (with a special interest in mycology and plant pathology) IN BOTANY at the University College of Ghana—The Secretary, University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 3).

PROFESSOR OF ANIMAL HUSBANDRY; and a LECTURER IN VETERINARY MEDICINE at the Veterinary College, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (January 7).

CHAIR OF ZOOLOGY—The Registrar, The University, Sheffield (January 11).

RESEARCH CHEMIST (with a university honours degree in science with chemistry or biochemistry as a major subject, or equivalent qualifications, and preferably research experience in physical chemistry) AT THE IRRIGATION RESEARCH STATION (C.S.I.R.O.), Merbein, Victoria, Australia, to carry out investigations into the dipping, drying and processing of vine fruits with special reference to problems of diffusion kinetics in the transfer of water through organic membranes such as the waxy coating of the grape—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 490/62 (January 11).

CHAIR OF SOCIAL ANTHROPOLOGY in the Department of Anthropology, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 13).

ASSISTANT LECTURER (with a degree or diploma in horticulture) IN HORTICULTURE—The Registrar, Massey Agricultural College, Palmerston North, New Zealand (January 31).

LECTURER (with experience of research in organic, inorganic or physical chemistry, or in an appropriate branch of physics) IN COLOURING MATTERS—The Registrar, The University, Leeds 2 (February 22).

ASSISTANT PHYSICIST (with good academic qualifications in physics and mathematics) IN THE UNIT OF CLINICAL INVESTIGATION, Royal North Shore Hospital, Sydney, Australia—Dr. C. W. Wilson, Physics Department, Westminster Hospital Medical School, London, S.W.1.

BIOCHEMIST, Senior or Basic grade (with a B.Sc. degree with honours in chemistry or biochemistry or equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

ELECTRON MICROSCOPIST IN THE BIOLOGICAL LABORATORIES, Harvard University, to collaborate in research with members of the department—The Chairman, Electron Microscope Committee, Biological Laboratories, Harvard University, Cambridge, Mass., U.S.A.

ENTOMOLOGIST (with a natural science degree from a British university and preferably a knowledge of tsetse, particularly *Glossina morsitans*) IN THE VETERINARY DEPARTMENT of Northern Rhodesia, for duties involving tsetse surveys and identification of species; field observation on seasonal distribution and habits of tsetse flies, particu-

larly *Glossina morsitans*; and duties in connexion with the control of the species—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.67/408/015.

HEAD (with high academic qualifications in mathematics, with teaching and research or industrial experience, and preferably specialized in statistics and/or numerical analysis) OF THE DEPARTMENT OF MATHEMATICS—The Principal, Technical College, Queen Street South, Huddersfield.

JUNIOR TECHNICIAN/TECHNICIAN (preferably with an interest in biochemistry) IN THE CLINICAL PATHOLOGICAL LABORATORY—The Secretary, The National Hospitals for Nervous Diseases, Queen Square, London, W.C.1.

LECTURER (with teaching and research experience, preferably in applied entomology or soil geology) IN AGRICULTURAL ZOOLOGY—The Registrar, The University, Nottingham.

MATHEMATICAL PHYSICIST OR MATHEMATICIAN (capable of carrying out independent research without supervision) to join a research team engaged in studying point defects in metals with special reference to radiation damage—Prof. J. G. Ball, Metallurgy Department, Imperial College, London, S.W.7.

MICROBIOLOGIST and a CHEMIST (with a good honours degree in an appropriate branch of natural science, and preferably with at least two years suitable postgraduate experience or training) IN THE DEPARTMENT OF AGRICULTURE, Federation of Nigeria, to carry out team research into the improvement of soil and crops under high rainfall conditions—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/14/046.

PHYSICIST, Senior grade (with an honours degree and appropriate previous experience in hospital physics), IN THE RADIOTHERAPY DEPARTMENT, which includes an Isotope Laboratory—The Group Secretary, Oldchurch Hospital, Romford, Essex.

RESEARCH ASSISTANT (preferably with some biochemical knowledge), to work on experimental pathology problems—The House Governor, The London Hospital, Whitechapel, London, E.1.

SENIOR BIOLOGY MASTER—The Headmaster, King's College, Taunton.

SENIOR LECTURER IN THE CHEMISTRY DEPARTMENT—The Bursar, Royal Agricultural College, Cirencester.

SENIOR SCIENTIFIC/SCIENTIFIC OFFICER (with a first or second-class honours degree in physics or metallurgy and some research experience), to carry out basic research on the alloying behaviour of radioactive metals—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A/1421/34.

STATISTICIAN (with a good honours degree in mathematics or statistics), for biometrical research and consultation in the Section of Statistics—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 57/9.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Northern Advisory Council for Further Education. Tenth Annual Report, 1956–1957. Pp. 36. (Newcastle-upon-Tyne: Northern Advisory Council for Further Education, 1957.) [189

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 2 (No. 12): The Scottish Carboniferous Eurypterida. By Dr. Charles D. Waterston. Pp. 265–288+4 plates. 10*s.* 6*d.* Vol. 63, Part 2 (No. 13): Crystal Growth of Forsteritic Olivine in Magmas and Melts. By H. I. Drever and R. Johnston. Pp. 289–316+2 plates. 10*s.* 6*d.* Vol. 63, Part 2 (No. 14): The Tertiary Dolerite Plugs of North-East Ireland—a Survey of their Geology and Geochemistry. By Dr. E. M. Patterson and Dr. D. J. Swaine. Pp. 317–332. 6*s.* (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) [189

White Fish Authority. Report on an Experiment into the Freezing of Fish at Sea. Pp. 65+6 plates+7 figures. (London: White Fish Authority, 1957.) 5*s.* [189

Planning, Vol. 23, No. 414 (16 September, 1957): Designs for Europe. Pp. 177–196. (London: Political and Economic Planning, 1957.) 2*s.* 6*d.* [189

Royal Institute of Chemistry. Geographical Index to the Register of Fellows and Associates. Pp. ii+94. (London: Royal Institute of Chemistry, 1957.) [189

Institute of Sewage Purification, Midland Branch. Symposium on Trade Wastes held at the University of Birmingham on 9th April, 1957. Pp. 112. (London: Joint Secretaries, Institution of Sewage Purification, 1957.) 10*s.* [189

Department of Scientific and Industrial Research. Building Research 1956: The Report of the Building Research Board with the Report of the Director of Building Research. Pp. vi+72+19 plates. (London: H.M. Stationery Office, 1957.) 5*s.* 6*d.* net. [189

Institute of Personnel Management. Annual Report, 1956–57. Pp. 19. (London: Institute of Personnel Management, 1957.) [189

A Survey of Fellmongering, Calf Skin and Hide Production, and Leather Manufacture in New Zealand and Australia. By Henry Phillips. Pp. v+38. (Egham: British Leather Manufacturers' Research Association, 1957.) 7*s.* 6*d.* [189

Department of Scientific and Industrial Research. Scientific Research in British Universities, 1956–57. Pp. vii+405. (London: H.M. Stationery Office, 1957.) 22*s.* 6*d.* net. [189

Current Medical Research: a reprint of the articles in the Report of the Medical Research Council for the year 1955–56. Pp. 56. (London: H.M. Stationery Office, 1957.) 2*s.* 6*d.* net. [189

Aero Research Technical Notes. Bulletin No. 177 (September, 1957): Yachts and Cruisers: Some Larger Craft Glues with 'Aerolite'. Pp. 8. (Duxford: Aero Research, Ltd., 1957.) [209

Transactions of the Zoological Society of London. Vol. 29, Part 1 (August, 1957): A Further Study of Dentine. By W. Warwick James. Pp. 45+10 plates. (London: Zoological Society of London, 1957.) 50*s.* [209

The Pensions Problem: a Statement of Principle and a Review of the Labour Party's Proposals. Pp. 15. (London: The Life Offices' Association; Edinburgh: Associated Scottish Life Offices, 1957.) [209

Other Countries

Commonwealth of Australia. Department of Supply: Research and Development Branch. Defence Standards Laboratories. D.S.L. Technical Note 42: A Switched Bridge to Measure the Voltage Coefficient of Resistors. By J. Wilbur-Ham. Pp. 4. D.S.L. Report 220: The Estimation of Wool Quality from Measurements of Fibre Diameter. By W. R. Hindson and F. S. Young. Pp. iii+8. D.S.L. Report 221: Tensile Testing of Textiles: a Comparison of Constant Rate of Loading and Constant Rate of Traverse Tests on Some Wool and Cotton Fabrics. By W. R. Hindson and J. A. Wilding. Pp. iv+6. D.S.L. Report 222: The Effect of Climatic Conditions on the Weathering of Plants. By K. R. Bussell and J. R. Rischbieth. Pp. iv+13. D.S.L. Report 223: Volatile Corrosion Inhibitors for Protective Packaging. By A. B. Cox and E. C. Kuster. Pp. iv+10. D.S.L. Report 227 A Pulsed Resistance Bridge for the Measurement of the Voltage Coefficient of Resistors. By Dr. R. E. Bauer, A. C. Gray and E. Laurence. Pp. 12. (Maribyrnong Department of Supply, Defence Standards Laboratories, 1956 and 1957.) [199

Connecticut Agricultural Experiment Station, New Haven. Bulletin 596: The 58th Report on Food Products; and the 46th Report on Drug Products, 1953. By H. J. Fisher. Pp. 59. Bulletin 597: Commercial Fertilizers—Report for 1955. By H. J. Fisher. Pp. 67. Bulletin 598: Report on Inspection—Commercial Feeding Stuffs, 1955. By H. J. Fisher. Pp. 110. Bulletin 599: Influence of Drying Rate during Curing on the Physical Properties and Quality of Shade-Grown Tobacco. By A. Boyd Pack. Pp. 31. Bulletin 600: Plant Pest Handbook: a Compendium based on findings of research in Plant Sciences for Three-quarters of a Century. Pp. vi+194. Bulletin 601: Studies of Mineral Balance as related to occurrence of Baldwin Spot in Connecticut. By Philip Garman and W. T. Mathis. Pp. 19. Bulletin 602: The 59th Report on Food Products; and the 47th Report on Drug Products, 1954. By H. J. Fisher. Pp. 68. Bulletin 603: Commercial Fertilizers—Report for 1956. By H. J. Fisher. Pp. 62. Bulletin 604: Apple Maggot Control Studies. By Philip Garman. Pp. 20. Bulletin 605: Report on Inspection—Commercial Feeding Stuffs, 1956. By H. J. Fisher. Pp. 109. (New Haven, Conn.: Connecticut Agricultural Experiment Station, 1956 and 1957.) [199

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Göteborgs Kungl. Vetenskaps- och Vitterhets-Samhälle. Reports of the Swedish Deep-Sea Expedition 1947–1948. Vol. 9: Sediment Cores from the Indian Ocean. No. 1: Diatoms from Equatorial Indian Ocean. By R. W. Kolbe. Pp. 50+4 plates. (Göteborg: Elanders Boktryckeri Aktiebolag, 1957.) 15 Sw. kr. [199

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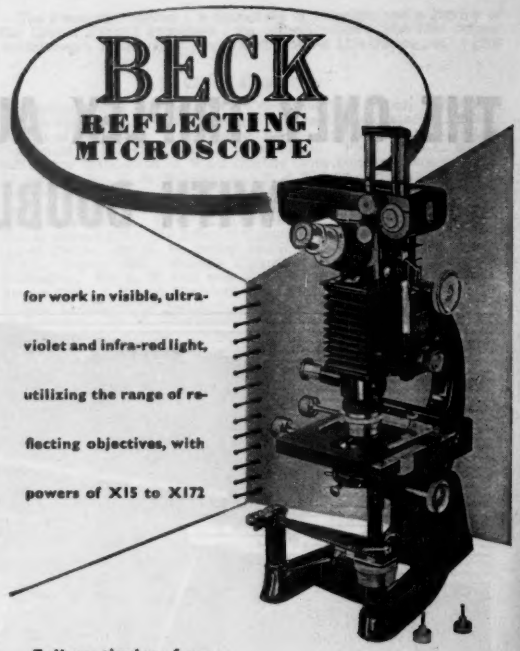

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